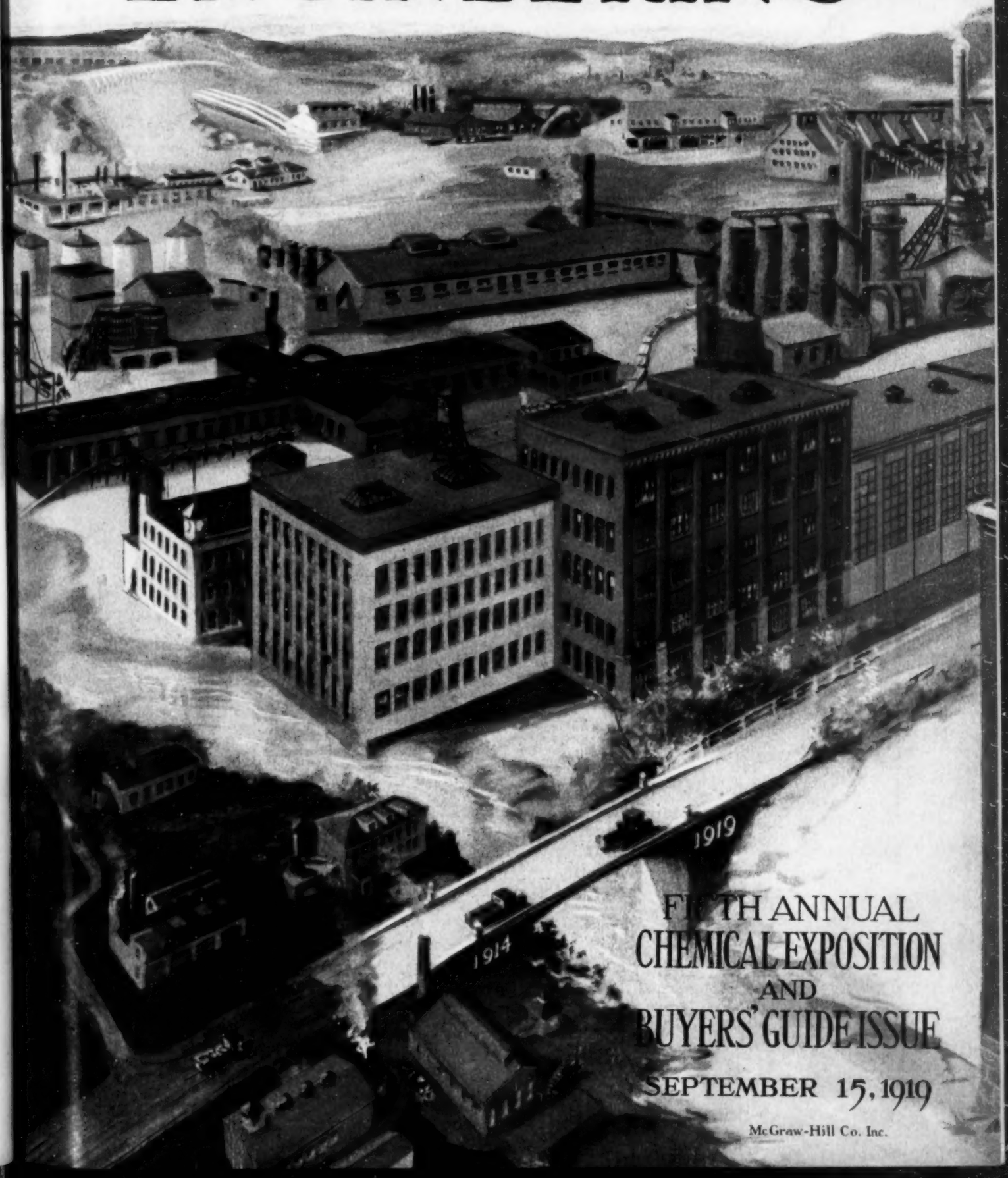
CHEMICAL & METALLURGICAL ENGINEERING



FIFTH ANNUAL
CHEMICAL EXPOSITION
AND
BUYERS' GUIDE ISSUE

SEPTEMBER 15, 1919

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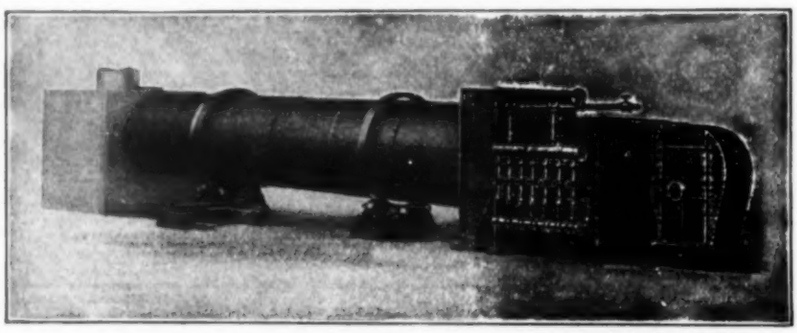

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Chicago—Host to Science and Engineering

CITIES, like individuals, have character. Like individuals, also, they may be born with it, acquire it or have it thrust upon them. Furthermore, they have the blessed privilege of changing their characters if, perchance, they have been unfortunate in their first efforts at character building. Mention any great or prominent city, and instantly, if you are familiar with it, its leading characteristic flashes across your mind. Thus, to us, Chicago typifies Industry, and it is as a great industrial center that we think of her in the last week of this month, when she becomes host to scientists and engineers whose work forms the foundation for many of the industries in her vicinity. We can easily forget her appellation of the Windy City; we can pass by her vaunting "I Will" and substitute therefor a more appropriate "I Do"; and we can even forget such an occasional misfortune as an alleged pro-German mayor; but we cannot wholly obliterate our recollection of the hum of genuine industry that vibrates in her atmosphere, nor forget the mental impression that a tremendous production of the country's needs comes from within her confines or adjacent communities. Chicago typifies Industry.

It will tax even a great industrial, not to say industrious city, however, to give adequate attention to a large exposition and five conventions in the same week. We recall no other instance of such a conjunction in the history of scientific and engineering societies, and in some respects we hope that it will not recur in the near future. Good and impressive as it may be, it nevertheless taxes the ability of many who are interested in two or more of the events which are scheduled for simultaneous occurence; and it leaves one with a sense of indigestion, if indeed the prospect of so plenteous a program does not dull the edge of appetite and lessen the pleasure of anticipation.

The complete program for the week of September 22 appears elsewhere in this issue. The central figure is the Fith National Exposition of Chemical Industries, in conjunction with which will be held the regular meetings of the American Institute of Mining & Metallurgical Engineers, the American Electrochemical Society, the American Ceramic Society, the Technical Association of the Pulp & Paper Industry, and the American Steel Treaters' Society. The last named society, in addition to its meeting, will hold a special exhibition of heat-treating appliances and heat-treated products at the Seventh Regiment Armory. The Chemical Exposition will be held at the Coliseum and First Regiment Armory, and the meetings of some of the societies will be held there also. Details are given elsewhere in this issue.

The four North Central States, of which Chicago is practically the geographical center, are the subject of considerable attention in this issue of CHEMICAL & METALLURGICAL ENGINEERING. Already a great industrial region, we believe that it is destined to increase in importance and power, and assume a larger place in the scheme of national economy. Centrally located and having unexcelled rail and waterways, the factors are all present for utilizing in the highest degree the natural resources of the region in the shape of minerals and cheap power. Intelligent labor is plentiful, education is at hand in many forms, the spirit of scientific research is exemplified in State and national laboratories and institutions, and there is plenty of opportunity for professional intercourse among men similarly minded. It is with the purpose of familiarizing our readers with this important region that we publish symposia on the industries and resources of Illinois, Indiana, Michigan and Wisconsin. Those visiting Chicago during the week of September 22 will have an opportunity to make short excursions into the adjacent territory with the scientific and engineering societies, and thus visualize more clearly the conditions which we have tried to portray by word and illustration.

American Chemists In Peace Session

THE fifty-eighth meeting of the American Chemical Society at Philadelphia may be recorded as a distinguished and important event. Not only were the papers timely, but there were general features which could not remain unobserved by any thoughtful chemist who attended the convention. Of the general features we think the most noteworthy was the spirit of resolution that dominated the meeting. In April at Buffalo many members were still in uniform and had hardly returned to their normal work. Industrial chemists seemed still to be on the springboard, swinging their arms. Now they have jumped in and are swimming. There was no professional boasting. Everybody knows that the waters are deep and the goal distant; but the men are resolute.

Another note was the greater sense of the dignity and the public responsibilities of the profession. It is said of Professor TYNDALL that he had a faithful Scotch servant who rapped at his door every morning, uttering aloud the message with an unctious Scotch burr: "Ar-r-rise, sir! Ar-r-rise! 'Tis 7 o'clock and ye have a g-r-reat wor-r-rk to do this day!" One could almost imagine that the ghost of the old Scotchman had been

passing before the doors of American chemists, declaring his message.

Too much praise can hardly be accorded to President NICHOLS and his able collaborators among the directors and the advisory committee, and to the Philadelphia and Delaware Sections for the completeness of the arrangements. The value of a man of inspiration at the head is sure to be reflected all along the line, but the earnestness and seriousness of the meeting extended far beyond any single man or group of men. A ringing note, however, was struck by the president in his call to organized labor, in response to the resolutions of the American Federation, to join with the Society in bringing about that quality of use and understanding of science which it demands. It was a hearty and honest call, made with the welfare of all in view.

Repeated again and again was the demand that chemsits be men of broad and abundant culture. The reasons given for this are twofold: that in research a trained and active imagination is required, and in industry, it is the chemist who represents to all the men employed the scholastic and philosophical elements of manufacture. Here indeed, as one of the speakers at the banquet emphasized, the man of culture is most needed. Many of the men who work with their hands have not trodden along the delectable paths of life. Many feel that they have not had a fair chance, and many indeed are right; they have been unfortunate in their surroundings. It is here that the chemist who, being proficient in the greatest of the arts, which is the art of living, may function to that betterment of this war-weary and distressed world which is the heart's desire of all good men.

The Potentiality of A Glucinum Industry

IN 1902 Mr. J. H. L. VOGT stated in the *Transactions* of the American Institute of Mining Engineers, vol. 31, p. 128, that between 0.01 and 0.001 per cent of the entire earth's crust is glucinum. In DANA'S classical "System of Mineralogy" the enumeration of localities where various glucinum minerals are found shows that they comprise a large list; while Bulletin No. 624 of the U. S. Geological Survey, on "Useful Minerals in the United States," shows that we have a relatively large quantity of glucinum minerals in our own country. In addition to this information regarding the occurrence of glucinum and its minerals, we have available many experimental data on the production and on the valuable properties, *sui generis*, of the metal, its salts and alloys.

Under these circumstances one might be led to expect that the glucinum industry is already a *fait accompli*, whereas in reality as long ago as June 14, 1916, Dr. J. W. RICHARDS stated in a paper read before the American Institute of Chemical Engineers that "dealers in rare chemicals will charge you, at present, $300 per ounce for a specimen of it" (glucinum). And in the *Revue de Chimie Industrielle* for June, 1919, we observe the prophecy: "A day will come when its [glucinum's] uses will probably increase considerably. It is only a matter of realizing the economic conditions of production and price."

These facts will prove of interest to those who have at heart the potentialities of new industries. Elsewhere in this issue we publish an extensive compendium of our chemical and metallurgical knowledge of the metal, covering the subject from the time of the element's discovery up to a very recent date. We hope and believe that it will stimulate interest in the subject and contribute in some degree to the establishment of a glucinum industry in this country.

The Fallacy of Class Distinctions in Chemistry

IN A notice issued some time since by the New Jersey Chemical Society it was recorded that "In order to promote contact of the industrial chemists with teachers of chemistry in the State of New Jersey, the committee on membership announced that those engaged in educational work, both collegiate and preparatory, would be welcome to membership in the Society."

We are glad to learn it. And if it indicates that the founders thought to make the Society a body of technical chemists exclusively, it is evident that they have resolved to correct the error.

We have been very fortunate in this country in keeping men engaged in pure and applied chemistry within the same organizations. The only difference between the two pursuits, as has often been repeated, is that in pure science one selects his own problem and takes his own time over it, while in applied science his problem is given to him and his time is limited.

There is no room for snobbery in either division. Let us imagine a man engaged in pure research who scorns industry as a dancing master scorns rubber boots and who declares himself to have "no interest in anything that is useful"; let us imagine him as soaking in soothing unreasonableness and ignorance of industry and its hot struggles that kill the weak and exalt the strong. How he behaves is a matter of taste, but so long as his work is important he cannot keep his work from counting in industry.

We declare that it is impossible to keep industry away from pure science, provided always industry follows research as it should. Of late we have found the demand growing urgent in properly conducted industrial research laboratories for advanced physical chemists. The time saved and the unnecessary experiments that are avoided by profound scholarship are no less than amazing. It is right here that the chemical philosophy of such savants as THEODORE W. RICHARDS, JULIUS STIEGLITZ and other great teachers comes into play. Abstract studies into the nature of chemical reactions have blazed the trail for many an industrial advance. No man who takes a forward step along the ways of pure science can keep enlightened industry out of his tracks. Such a pioneer does not need a factory number.

As for snobbery on the other side—the belief that because industrial chemists who have passed the stage of hack work are different in any particulars of merit from those who teach because they are better paid—it is absurd. The capacity for administration is an endowment rather than an art to be acquired; and so is teaching. So, too, is the capacity for research. They are gifts, like red hair, and some few of us have the first of these blessings, a few have the second and a few enjoy the third. The vast majority of mankind are better off at other tasks than any of the three mentioned. But the work of each is needed, and all function best when they are in association and live in comity. We have seen good time wasted in teaching students of chemical engineering how to operate simple apparatus which they might have learned from a skilled

laborer; the while a course in physics which would have opened their minds to what they needed most was being neglected.

There is every reason why we should avoid class distinction in chemistry. We hope the Princeton and Rutgers faculties and the high school teachers generally will join the New Jersey Society. It will be an excellent thing for the teachers to see the many applications of their subject in everyday doings and things. It will enable them to blow the breath of life into their work and to explain the reason why abstractions that seem to be only "mind-improving" school book agonies are in constant use in daily life. For the chemist in the works whose operations are likely to be circumscribed by the limitations of routine practice, it will be an inspiration to foregather with men who select their own problems and dig into the unknown.

Recognizing the Importance Of Non-Metallic Minerals

A FAVORITE expression of a friend of ours is that "periodically we ought to revise our prejudices." Likewise we ought periodically to extend our vision, revise our classification of essentials and non-essentials, and readjust our concept of the relative importance of things. If prejudices are susceptible of revision, and we may pause to remark that they are, then certainly it is possible occasionally to take stock of our industries and their needs and revise our estimate of the relative importance of, let us say, minerals.

We venture the assertion that there is a wider familiarity with the production, treatment and uses of metallic minerals, such as galena, blende, hematite, chalcopyrite and pyrite, than with such non-metallic minerals as dolomite, talc, feldspar, fuller's earth and gypsum. The reasons are obvious. Minerals of the first class produce the common metals, and have the metallic luster and other physical properties that distinguish them, even for the layman, as something of importance in the earth's crust. The non-metallics, on the other hand, are apt to lack even distinguished appearance, being earthy and unattractive. Furthermore their uses are likely to be less apparent, and consequently they are not regarded as economically important. Not the least factor in drawing attention to the metallics is the amount of research that has been devoted to them by both Government and private agencies. In fact the pendulum of mineral research has been swinging so strongly in the direction of the metallics that we have been in danger of forgetting the importance of the non-metallics.

If the reader is interested in gaining an insight into the importance of the non-metallics in our industrial life, he will read the contribution of Mr. LADOO, published elsewhere in this issue. The non-metallics are the basis of many of our chemical industries; they form the raw materials out of which the finished product is fashioned, or, quite as often, they are used in the form in which they are taken from the earth, requiring no beneficiation or treatment whatsoever. Oftentimes their properties are obscure and the reason for their action poorly understood. This leads to rule-of-thumb application, to empirical use, and often acts as a bar to progress.

The great need of the non-metallic mineral industry in the United States today is systematic research prosecuted with as much intelligence and vigor as has been expended on metallic minerals for the past decade or more. The Bureau of Mines is an excellent agency to undertake this work as far as its national aspect is concerned. State institutions of learning can supplement the work either in co-operation with Federal authorities or by independent investigations on minerals of importance within their own borders. We believe it is not too optimistic to predict that ten years of research of the kind indicated will place our chemical industry and allied industries on such a footing as will establish them permanently in competition with similar industries in other countries, provided always that we have raw materials of equal quality and quantity.

Mechanical Charging Of Lead Blast-Furnaces

IT IS popularly supposed that it is more difficult to run a lead blast-furnace successfully than one smelting copper or iron ores—at least the operators constantly emphasize the extreme necessity of a most uniform charge column. DWIGHT long ago pointed out that a distinct gradation from fine at the side walls to coarse at the center is a prime essential of good furnace work, but no considerable segregation in sizes or in materials is allowable either vertically or longitudinally, else overfire and serious losses in recovery will ensue. Not that a uniform charge is not extremely desirable on any furnace, for it unquestionably is, but metallurgists believe that a lead furnace will stand less abuse than any other common smelter.

Twenty-five years ago hand-charging was universal practice; ores were bedded by hand, carted and dumped on the furnace floor, there to be shoveled into the furnace top at a total expenditure of perhaps one hour's labor per ton of charge. In its entirety this labor-wasting system is now seldom encountered, although mechanical devices for bedding are even yet rare. The first long step in advance instituted a charge car to be filled with several tons of miscellaneous materials by barrows, then to be hauled to the furnace and dumped into the shaft. In this manner about three tons of charge can be put into a furnace per man-hour. Labor efficiency is again tripled by most modern systems of mechanical assembly and charging.

Arguments against an exclusively mechanical system on the ground that it causes segregation lose weight when coming from men who are using a charge car not only narrower but actually much shorter than the furnace top. This is said with all due regard to the ideas of those who wish the charge car distinctly smaller than the furnace cross-section, so that it can be placed as desired, into this or that corner, side, or end of the furnace, to humor the peculiarities of accretion and charge descent. But are not these abnormalities mostly due to inferior charging? Then why spend good money in getting a correct mixture to the charging floor, and waste it in one fell drop?

Various causes other than inertia have prevented ready adoption of labor-saving devices at lead plants. Differences in general plant arrangements make it impossible to copy widely a successful layout, while variation in furnace top construction requires special design of charge car itself, so that a car very successful on a hooded furnace would be useless on another whose gases were drawn off below the floor or through a thimble. Mechanical handling in general is accompanied by rough handling, which is disastrous to the friable sinter forming such a large proportion of the present

burden. Again, since no device will be perfect, irregular furnace operation will require at times uneven corrective charges; in other words, the system to give uniform charges should be flexible enough to give non-uniform charges when desired to control the furnace action.

Combine all these requisites in a layout which will minimize the cost of plant, operating charges and the handling of materials, and the problem is by no means an easy one. The Dwight-Messiter system so successfully operating in copper smelters has not found much favor in lead plants, principally because the extensive conveyor system involves much handling—that is, many drops—and because certain portions of the charge, such as sinter, flux and coke, do not require bedding, in fact are preferably placed in the furnace in layers. Therefore it seems probable that, for economical construction, sinter can be passed through bins of fair reserve capacity, while limerock, slag, coke, or other materials of uniform analysis can be merely dumped from a trestle, and drawn off into a tunnel below, the toes and ends of the piles remaining as surplus emergency stock.

A series of individual bins have in certain instances been successfully substituted for the time-honored ore-beds. They are much more expensive to install, especially if each has a weighing mechanism attached, and they require excessive switching by the charge-collecting car. If but a hundred pounds are drawn off for each charge, a small shipment is quickly exhausted. Ore-beds containing a thousand tons of material or more have many points of metallurgical advantage, if only in making for uniformity in furnace operation. Excessive labor is not essential for their assembly; a rectangular tank-like bin covered by a tripper on a low traveling bridge will build as good a bed as can be done by the most skilful laborers.

So much for the storage end. The engineer will next concern himself with getting the material into a charge car in uniform layers. Mechanically this may be done by bringing the charge car to the stock, or *vice versa*, either by rail or conveyor. As before noted, the first mentioned scheme has been installed successfully, but requires much switching and expensive maintenance of a scale car, or if a rugged hopper car is used, will involve many costly weighing devices. By the second plan, if a series of smaller receiving bins are assembled over a single loading track, a minimum of charge-car movement and a very few "weighing-off" conveyor-feeders would do the work. Either arrangement can closely simulate successful hand-filling practice and by regulation of speed of car or ore-stream, "humps" of material can be built up as required by the furnace man for corrective purposes.

To take the best advantage of the close control thus available in the condition of the charge as it arrives at the furnace mouth, it is essential that the burden be placed into the furnace in practically the same condition as it is delivered. That this is only approximated is easily seen from present arrangements. The wheels of the charge car itself may be about two feet above the floor, carried on a transfer, while the shaft may be open eight to ten feet to the bottom of the smoke flue. A six-ton charge dropping sheer ten feet would appear to be disastrous to the stoutest furnace construction—as a matter of fact, the charge runs slowly out of slots in the car, and strikes a deflector on its way down, not only reducing the impact but correcting the segregation inevitable from center charging.

A charge properly assembled should not need distributors or deflectors to get it into a lead blast-furnace correctly. A car with a real quick-opening flat drop-bottom, of the same cross-section as the furnace mouth, should be able to place the charge into the furnace in the same condition as it arrives. The impact of the falling mass would then be a factor of importance and could most readily be reduced by a low-hung car entering a hooded top, with the burden kept as close to the rail as metallurgical circumstances will permit.

Thus would the maximum value of mechanical charging be attained. It is evidently independent of the method of storing the components, of gathering them or getting them into the charge car. The main thing is to get the materials into the furnace in a pre-determined and controlled manner. At present the deflector controls the situation, but the question is raised, Could not the distribution be more properly done under closer control and at more leisure in a charge car so designed as to dump quickly and without further segregation?

Co-operative Industrial Research Laboratories

EARLY last winter Mr. C. E. MEES, head of the research laboratory of the Eastman Kodak Co., delivered an address in New York on Research Laboratories in Industrial Establishments. He spoke from the vantage of ripe and successful experience. He gave many valuable hints, and pointed out not a few hazards in well-meant laboratory practice. It was an excellent address. Later Mr. P. G. NUTTING, head of the Westinghouse research laboratory at Pittsburgh, presented a paper on Institutes of Applied Science, in which he outlined in considerable detail the qualifications which a research institution should possess to be efficient in "turning out experts and in establishing vital and fundamental principles." He outlined seven principal types of research institutions that are already in existence in this country, and concluded his paper with enumerating the benefits to be gained by a great series of such organizations which should cover over thirty fields of applied science. His sketch of plans for the conduct of such co-operative institutes was illuminating, and in many respects admirable.

Just now, however, we want to emphasize the immediate need of research in industries, the need of it today; in our native clays, for instance; in the cement industry: in pulp and paper; in refractories, despite the work already done, for the prosecution of what VICTOR MEYER called pyrochemistry; and in many other directions. When captains of industry are so minded they can get a first line on what they need in many different ways. The main thing required is intelligence at the source. Industrial establishments must retain a reasonable measure of individuality, and if this is not to be found in standard products it may be looked for in methods. Natural raw materials cannot be economically standardized; we have to take them as they come with varying geologic histories and of diverse chemical composition.

And while our interest is in industries as made up collectively of many plants, we cannot ask the individual manufacturer to consider his own responsibilities lightly, or as merely incidental to the whole. He must

bear his own establishment constantly in mind, if he is of the right sort and wants to keep ahead of the game. The way to do this is by progress rather than by secrecy. Given two plants, one modern and well administered, the other antiquated and operated by rule-of-thumb methods, it takes no gift of prophecy to foretell which will succeed and which fail. It is not secrecy that counts; it is capacity. The great purpose of co-operative research is to keep up the tone of the whole of an industry. This is essential for national reasons, in order to prevent failures and the consequent miseries of unemployment no less than to avoid that general ill-repute into which the incompetent few can bring all engaged in any single line of manufacture. The really able manufacturers are those who see to it that they keep ahead. They acquaint themselves with principles rather than with details of which their competitors are ignorant. They ascertain if any one else is working along their particular lines, whether in universities, private laboratories or endowed institutions. This is not accomplished by spying or underground methods; it is the result of being informed, of speaking the language, of familiarity with the literature—and in large part it is the reward of intelligent curiosity.

In short, the really able manufacturers are men of science, or they are closely associated with such persons of standing. In this wise they become familiar with the philosophy of their various processes. Also they attend meetings which would provide no enlightenment to their unreceptive competitors because the latter class do not grasp the vast complex of relevancies in applied science. The competent always have something on the stocks, in one laboratory or another, if not in their own, and they reap rich harvests accordingly. Old Uncle DANIEL DOLLARDOODLE never could make out how they turn the trick.

The White House Conference on Labor

EARLY next month twoscore or more carefully selected men will gather in Washington at the invitation of the President to seek a solution of the labor problem. Precedent does not encourage one to be hopeful that such a gathering, or any other, can solve the problem. Great questions like this do not usually have an "answer" that is adequate, requiring only search that it may be found. Ten years ago there was the White House conference of Governors, to consider the subject of conservation. The interchange of views undoubtedly did good, but no comprehensive program resulted, because such a program, to be effective, required the active co-operation of a very large number of men, with very divergent interests.

It is quite true that the coming conference could recommend legislation by Congress, but it is extremely doubtful whether any vital legislation that would be recommended would be enacted. Even were Congress disposed to legislate, it would be very difficult to draw up desirable legislation. Suppose, for instance, it should be desired to legislate against strikes, as it is desired to do in the case of the railroads. How could a line be drawn, defining in what industries or at what plants strikes must not occur?

An awkward feature of such a conference is the matter of representation. It is very difficult to find real representatives of unorganized labor, while representatives of organized labor are exponents of a system that strikes at the very roots of industrial peace. There can be no true co-operation between employers and organized labor, because organized labor refuses to recognize quality.

An illustration will serve to emphasize the vital importance of this fact. There was a time, say 15 or 20 years ago, when the average steel mill produced little steel except ordinary "mild steel," which covered a multitude of characteristics little known and still less regarded, while some of them produced what was broadly known as "rail steel." The buyer had to take what he got. Gradually it developed that there was money in suiting the steel to the special requirements of the consumer. At first the steel mills yielded rather grudgingly to the demands of customers that they be furnished steel a little different, but soon this feeling was supplanted by an active desire to meet the precise requirements of the user. Instead of being content with filling, or attempting to fill, the expressed desires of the buyer, many mills established research departments, resulting in the mill being able voluntarily to offer the customer or prospective customer a steel better adapted to his requirements than the buyer had been able to conceive.

Thus there has been established co-operation between the seller of steel and the buyer of steel, and this co-operation has proved mutually advantageous. More steel is being made and consumed to-day than if this co-operation had not been developed.

The system of organized labor presents no such co-operation. It strives to prevent co-operation. The pay per day is to be so much, no matter what the day's service amounts to. No day's work is worth more than another day's work. It is as if the seller of steel should say: "Here is our steel. If your axle is not strong enough, buy more steel and make your axles larger. If 25 per cent of the sheets break in forming, buy one-third more sheets. That will give the steel mills more work."

What is desirable is the replacement of the system of organized labor by a better system, but in all probability organized labor will contribute the chief spokesmen for labor.

For some time there was a strong outcry against "paternalism" on the part of the United States Government. OTTO H. KAHN delivered a very forceful address on "The Menace of Paternalism" before the convention, at Chicago, of the American Bankers Association, September 27, 1918. The address was reprinted in pamphlet form and was read with interest and approval by a great many thinking men. The "menace" has now almost died out, not chiefly because MR. KAHN spoke against it, but chiefly because practical experience has shown that it won't work.

Paternalism, however, is paternalism, whether it be government paternalism or not, and the fundamentals are such that it is as insufficient if it is the one kind or the other. Now, unfortunately, a large part of the defense of "open shop" employers against unionization is the paternalism these employers practice. What is done may be, and probably is, in itself altogether unobjectionable. It is "good work," so to speak, but it is not co-operation, and it is co-operation that is requisite. Can the coming conference at Washington devise a method whereby there will be co-operation between the employer as an individual and the employee as an individual?

Readers' Views and Comments

War Department Deserts Chemical Warfare Service

To the Editor of Chemical & Metallurgical Engineering

SIR:—The editorial in your issue of Aug. 15, entitled "War Department Deserts Chemical Warfare Service," prompts this letter. As a chemist, I sympathize with your attitude. I believe that such of the recent developments in methods of warfare that are usually described as "chemical warfare" should be the subject of continued study and research. And much of this should be done by chemists and physicists of the best training and widest experience. On the other hand, I do not believe it necessarily need be done by a distinct branch of the Army organization. My experience as a Captain in the Chemical Warfare Service, A. E. F., leads me to believe that the various activities of the Chemical Warfare Service, with perhaps one exception, could be performed satisfactorily by the ordinary departments of the Army. An enumeration of such activities, with their disposition according to my idea, may justify this statement.

The study of gas mask chemicals must be made, of course, by chemists and physicists. But why should not this, as well as the production of the finished masks, which is but a manufacturing proposition after all, be under the jurisdiction of the Ordnance Department? Likewise, why should not the chemical research necessary to the study and development of toxic gases, the engineering research necessary to their manufacture, and their manufacture itself, be functions of the Ordnance Department? Another important activity of the Chemical Warfare Service was the training of gas officers who were to be responsible for the "gas discipline" of the troops. It seems to me that this is a purely military matter that can be handled by regular line officers as part of their regular duties. Certainly scientists are not necessary for this duty. I am assuming, of course, that the professional training of these line officers will be modified so as to make them competent to do this. It will be necessary in this connection for some soldier-chemist to write a text on "Military Gases" of the same general character as Weaver's "Military Explosives."

As the offensive use of gas has become largely an artillery problem, artillerists can be instructed in the special uses of the various gas shells, as they are at present instructed in the particular uses of shrapnel and high-explosive shell. The offensive use of gas from mortars and projectors and the use of smoke has largely been in the hands of specially trained "gas troops" under the Chemical Warfare Service organization. But in my opinion there is no necessity for such classification; they could very well be called engineers, or even given an infantry classification and organized much as the machine gun units are, in their relation to the rest of the Army.

On the other hand, I believe that there should be on the staff of each division, or certainly of each army corps, a soldier-chemist, whose chemical training must be the very best, and whose chemical judgment must be matured by proper experience, whose duty would be to investigate personally the gas activities of the enemy in his sector, so as to keep his commanding officer of the War Department advised of gas developments during the campaign. There might even need to be an emergency laboratory available to these officers. But this should be so near the front as really to serve its emergency purpose; much too near the front to serve as a research laboratory. These officers might properly be classified as a chemical service. But their number would be so small that even in this case I believe it would be better to classify them in one of the existing departments.

Thus, it seems to me that the proper activities of the Chemical Warfare Service can be apportioned among the existing departments of the Army. Perhaps it is the plan of the Army to do this very thing, and to abandon merely the Chemical Warfare Service classification, not its activities.

B. B. FREUD,
Associate Professor, Armour Institute of Technology.
Late Captain Chemical Warfare Service, A. E. F.

Experimental-Retort Tests of Orient Coal

To the Editor of Chemical & Metallurgical Engineering

SIR:—I have just returned from my vacation and note that you have published "Experimental-Retort Tests of Orient Coal" in the Aug. 15 issue.

In the absence of Mr. McBride, who is at present away on vacation, I want to call to your attention that you omitted the special acknowledgment we gave Mr. Edwin Barnhart, engineer of tests for the Bethlehem Steel Co., who developed the retort, and Mr. D. H. Duvall, assistant chemist, who has conducted the retort tests for the company. We are indebted to them for their valuable assistance rendered at the time the tests were made.

I. V. BRUMBAUGH.

A Rapid Method for the Analysis of Red Lead and Orange Mineral

To the Editor of Chemical & Metallurgical Engineering

SIR:—In the July 15, 1919, issue of CHEMICAL & METALLURGICAL ENGINEERING exception is taken by Mr. Eric John Ericson as to the proper credit for the method used in a paper on "A Rapid Method for the Analysis of Red Lead and Orange Mineral" published in the *Journal of Industrial and Engineering Chemistry*, vol. 8, No. 3, page 237, March, 1916. It is Mr. Ericson's claim that I failed to give him credit for a prior application of the method as used. The method as used in that paper is taken from the third English edition of Treadwell and Hall's Analytical Chemistry. Reference was made to that edition so that it would be applicable to the latest publication of that book. If Mr. Ericson would acquaint himself with the literature on this subject, he would find that these reactions are described substantially as given in Treadwell and Hall's first English edition.

The question of the decomposition of PbO_2 by H_2O_2 was first discovered by Thenard and was first carefully studied by Brodie in 1850 (Brodie, *Phil. Trans.*, 1850, p. 759; *Chem. Soc. Quart. J.*, IV, p. 194; *Chem. Soc. Quart. J.*, VII, p. 304). As Thenard discovered hydrogen peroxide and studied its properties in 1818, this phase of the matter seems to have been common knowl-

edge for over a century. Brodie's work was a detailed study of the reaction:

$$PbO_2 + H_2O_2 = PbO + H_2O + O_2$$

This reaction is also mentioned in Watt's Dictionary of Chemistry, published in 1871, vol. 3, page 198.

In Treadwell and Hall's book credit is given to the method of Lux. In so far as the method under discussion deals with the decomposition of red lead by nitric acid, this is fully described by Lux in his paper on the "Gravimetric Determination of Minium," published in 1880, *Zeit. für Anal. Chem.*, 19. The other part of the reaction is described in Treadwell and Hall's book with no reference given, due probably to the fact that this matter was common knowledge for so long a time.

From a study of these references, it will be seen that I was correct in crediting the method as was done. It is to be regretted that anyone making the claims which Mr. Ericson has made would fail to make a thorough study of the prior work done on this subject. While his method is a most excellent one, he has probably claimed too great originality for himself. In the light of these earlier investigations the mere fact that Mr. Ericson used this method for a dozen years in the zinc industry, and on Joplin ores principally, does not establish the claim that he should be credited with the prior application of this method as it refers to the analysis of red lead and orange mineral.

At the same time, it is indeed strange that he has only made the discovery which he did in respect to the credit he presumes to be due him after more than three years, the original paper being published in March, 1916, while his letter appears in July, 1919. It is apparent he has shown a great disregard of former investigations and publications.

JOHN A. SCHAEFFER,
Chief Chemist.

The Eagle Picher Lead Co.,
Joplin, Mo.

Western Chemical and Metallurgical Field

Boulder County Tungsten

READERS interested in tungsten are undoubtedly acquainted with the fact that this specialized branch of metallurgical industry has been marking time for several months, but they may not know that the mines and mills in Boulder County, Colorado, are almost completely abandoned. This region, the most important American tungsten source, shows many after effects of the wild flight of market prices. Fabulous quotations early in 1916 produced a record tonnage by the use of unusual expedients, and when the market settled to a relatively narrow fluctuation during 1917 (around $24 per unit), a substantial output was forthcoming from the mines and mills developed during the boom. This price remained approximately stationary up to the end of the war, and was affording a good return, as may be surmised when comparing it to a pre-war price of $6 per unit. Unfortunately, however, when the War Minerals bill was under discussion in Congress, the prediction was freely made that Colorado ferberite would soon be selling for $30 per unit WO_3, a prediction never realized, but which caused many of the small leasers and operators to curtail their mining and hold back their concentrates in expectation of the higher price. This somewhat concerted action cut into the 1918 production, and the result was that when the larger producers began shutting down in the fall there was really but a modest amount of spot ferberite in existence.

Thus all the mills in the district are now shut down; the principal ones being the Wolf Tongue Mining Co., at Nederland; Vasco Mining Co. (American Vanadium Co.) at Tungsten; Primos Chemical Co., at Lakewood; Rare Metals Co., at Rollinsville; Tungsten Products Co., at Boulder, and the Red Sign Mill, at Ferberite. Operators, large and small, are waiting for a high tariff to exclude cheap Asiatic ores; meanwhile large quantities of the latter are being imported and will command the market for months to come, tariff or no tariff. However, there is little or no ferberite to be had, and many users require this pure mineral rather than the imported ore, high in tin, manganese and copper. A decided premium is therefore to be expected, which may well grow to a point where mining in the richer Boulder veins will again be possible. As a matter of fact, leased ore is now being taken from the Black Rose mine at Dry Lake, some 4½ miles from Nederland, and shipped to Denver for magnetic concentration to supply a sizable contract running over the balance of 1919. This may be the forerunner of a revival in ferberite.

Dr. Eckley and some of his associates at the University of Colorado were able to perfect a chemical process for the production of very pure tungstic oxide from impure materials, and their commercial plant (Black Metal Reduction Co.) at the mouth of Boulder Canyon has been in operation for nearly two years. They first bought up mill wastes from their immediate neighborhood, a fine, impure product which could not be cleaned by water concentration. This was subjected to an alkaline fusion, the mass then leached, the filtrate purified and finally WO_3 precipitated pure enough to pass the exacting demands of incandescent lamp makers. After the Colorado supply of low-grade tungsten was exhausted, some unsalable fines from Dakota were utilized. More recently good ferberite has been purified, but at present this plant is operating at half capacity on Chinese ore, laid down at the plant at a figure less than it can be delivered from mines a few miles away.

CHEMICAL & METALLURGICAL ENGINEERING has already published detailed accounts of the milling practice in Boulder County.* Briefly the process consists of crushing the ore for jigging to about ¼ in. so as to produce the minimum of fines. Jig tails are crushed to about 10 mm., classified, and passed over tables. Table sands are then reground and concentrated as slimes on vanners and canvas tables. Since these articles were published there has been little change in the accepted ideas on gravity concentration—flotation has not been adapted to these ores—but very gratifying results have been obtained by magnetic concentration, especially by the Tungsten Products Co. All its intermediates needing cleaning are dried and then carefully sized in a series of impact screens, and the sized material passed in a thin stream through 3-magnet Wetherell separators adjusted to the product being handled. The first cross belt picks out most of the iron at a low impressed amperage, the second picks up some magnetizable silicates at intermediate amperage, while the last at high density takes out a high grade concentrate, commonly averaging well above 60 per cent, and leaving a tungsten-free residue.

*S. Fisher, "Modern Concentration of Colorado Tungsten Ores," vol. 16, May 15, 1917, p. 559; vol. 17, July 15, 1917, p. 73.

The Tungsten Products Co. also has had success in manufacturing WO_3 by chemical methods and ferrotungsten in electric furnaces, its contracts for the latter having expired only recently. Its plant, in addition to producing tungsten compounds, is busy on experimental work on other electric furnace products. Ferrotungsten is produced by this company in knock-down furnaces of about 100 k.v.a. capacity. A steel shell about 4 ft. in diameter by 4 ft. high, split in halves, is tamped with a refractory lining and placed over a carbon terminal block flush with the floor. A little charge is shoveled in (ore, coke and flux), the single electrode lowered and current turned on. As the charge is reduced more ore is continually added through the open top; the metal accumulates as a button in the bottom of the furnace, while the small amount of slag is tapped periodically through the slot between shell-segments. Metal is left in the furnace, however, and it finally accumulates in the form of a short, thick cylinder, occupying perhaps half the furnace cavity. On cooling, the furnace is torn apart, the slag-free button broken under a skull cracker, further crushed by a steam hammer, and mixed by running through a screening bin and elevator system several times. Ferro is finally shipped to analysis in double canvas bags containing 80 lb. of the alloy.

Government Helium Plants

A recently issued pamphlet on the war work of the Bureau of Mines brings together the personnel and notices the main facts regarding their highly important work on helium. At our entrance into the war there was about 1 cu.ft. of the gas in bottles in possession of Dr. R. B. Moore of the Bureau, probably the available stock on this side. As a starter, however, the British Admiralty requested immediate delivery of 100,000,000 cu.ft., and a weekly supply of 1,000,000 cu.ft.!

Mr. G. A. Burrell, Prof. W. H. Walker and Dr. F. G. Cottrell successively directed the preliminary development of the plans for the so-called "argon" plants, and secured the co-operation of the Linde and the Air Reduction companies. Plants were constructed at Fort Worth, Texas, utilizing the well-known Linde and Claude processes, the former for producing daily 5000 cu.ft. of 90 per cent helium from 0.4 to 1 per cent natural gas, and the latter for producing 3000 cu ft. per day. Building operations were commenced in November, 1917, and gas was first produced in March, 1918. Both plants were able to make a gas of about 70 per cent purity, which was reprocessed in the Linde plant up to 92 per cent; this stage requiring some two months' experimental operation. Since that time about 200,000 cu.ft. of gas has been made, most of which was in drums at port ready for shipment at the end of the war. Plant 1 (Linde process) has since been dismantled, while the Air Reduction Co. operated a short time working out an improvement in the process, the Navy Department meanwhile taking physical possession of the plant.

Dr. R. B. Moore was given the direction of this work in June, 1918, and was actively in charge for about a year. The Bureau was especially interested in the process devised by F. E. Norton, which had been approved after careful investigation by the National Research Council. In this process triple-expansion engines are used, liquid is throttled and the heat interchanger and fractionating still are of new design. Multiple-expansion engines thus reduce the power for gas compression to a minimum. However, the development of a new process from laboratory size into the largest refrigerating plant in the world was attended with many difficulties, and the Norton plant (located at Petrolia, Texas) produced helium early in April, 1919. Gas of 21 per cent purity has been made, and it is confidently expected that high-grade gas can soon be produced by this plant on a large scale. A fund of $100,000 has recently been made available by the Army and Navy for necessary alterations to the plant and its operation as a production unit.

The Navy Department is now engaged in the design of the so-called "Production Plant No. 1" to be situated at Fort Worth. Its daily output will be 30,000 cu.ft., and a supply of 7,200,000 cu.ft. will be required for dirigible use. A modified Linde process will be used, the plant itself costing $1,700,000, besides $1,800,000 for a necessary pipe line. It is estimated that operating charges for the production required will total $750,000, and that the lease on the Petrolia gas field will cost $1,500,000.

Labor Troubles in Copper Camps

Rather interesting and unusual labor troubles are being endured in Nevada and Montana, but have been treated in radically different ways and with different results in the two instances.

During the last week in July, the shopmen and affiliated crafts of the Nevada Northern Railway, 125 in number, declared an unexpected strike for largely increased wages and certain unimportant changes in the conditions of employment. This railroad, as is perhaps well known, is owned by the Nevada Consolidated, and transports ore from its shovel pit to the mill at McGill, some 20 miles distant, as well as connecting the copper camps with Cobre or Shafter, stations in northwestern Nevada on the Southern Pacific and Western Pacific, respectively, 120 miles north. Although the trainmen were not striking, there was no one to keep the engines in repair or to coal the tenders, so that ore trains ceased to run almost immediately, and a shutdown of mill and smelter was in close prospect.

However, before the stock of ore was exhausted, other unionized employees, from steam shovel operators to converter punchers, united in an ultimatum demanding that a list of concessions and an increase of $1.25 per 8-hr. day be granted by a specific hour on July 20. The threat was carried out, but the management had anticipated the action, so that the simultaneous stoppage of work of 3000 men in every craft without exception caused no large property damage through frozen furnaces. The company offered an increase of 75c. per day, claiming that this brings the wages to within 25c. of pre-armistice levels, that it is all the present shaky copper market will warrant, and that it re-establishes a scale equal to or greater than the scale paid at any other camp. The men soon receded to a demand of about $1 per day increase, thus leaving but a margin of 3c. per hr. between work and idleness. Attempted mediation by Gov. Boyle of Nevada and Federal Mediator Davies failed to budge either party to the dispute.

General strike conditions did not become particularly oppressive until the inhabitants began to miss the train service connecting them to the outside world. By permission of the strike committee, trainmen were authorized to take out the passenger trains, but the master mechanic of the railway—the only one doing any engine hostling—was unable to get more than three

trains ready per week. Such conditions were admittedly temporary, however, and complete stoppage of service was in prospect.

A real idea of the gravity of the apparition confronting the citizens of Ely and McGill—300 miles by highway to the nearest considerable city—may be had from merchants' statements before the Railway Commissioners on Aug. 13, that they had supplies of staples for about a week, while dairy products and fresh meats were practically exhausted. One has but to pass through the region to realize that no supplies can be derived from the surrounding country. This condition at Ely but miniatures the state of the whole country in the event of a strike by the railway brotherhoods!

Settlement of the strike on the company's proposals was overwhelmingly voted by the employees after about a month's idleness, however, mining being resumed Aug. 29, and the smelter blowing in on Sept. 8.

A strike of metal workers and stationary engineers against the Anaconda Company on the other hand has not caused material curtailment of production—rather otherwise, strangely enough. Fortunately, the hoisting engineers in Butte are not involved, while mill and smelter men are continuing at work by virtue of signed contracts and tacit disapproval of the walkout by the metal trades. This difference came about over the negotiation of new contracts between company and the disaffected unions, the men feeling that they should receive $7 per day, while the company offers but $6.50. Minor questions are also at issue, but the wage rate seems to be the principal bone of contention.

The management has again employed tactics similar to those used in an electricians' strike three years ago; that is, they have called for volunteers among their technical staffs—draftsmen, engineers, chemists and research men—temporarily to take places of the missing mechanics. Of course it is impossible to man the shops completely, and no attempt is made to do any work except that connected with "trouble shooting" and the operation of power houses and substations. From the first, however, all the departments operated with accustomed smoothness, and in fact have readily absorbed the increased volume of ore delivered recently.

Some rather curious things have been demonstrated by this experiment. One is that one electrical engineer can satisfactorily replace about three electricians. Another is that the mysterious comings and goings of the regulation smelter mechanic are more camouflage than the performance of any necessary duties incomprehensible to the ordinary man of ingenuity.

Meeting of Electric Furnace Association

An important reorganization meeting of the Electric Furnace Association will be held at the Congress Hotel, Chicago, at 11 a.m., Monday, Sept. 22. Officers will be elected, and an open session held for discussion of papers on the commercial future of the electric furnace.

Eighth Annual Safety Congress

The National Safety Council will hold its Eighth Annual Safety Congress at the Hotel Statler, Cleveland, Oct. 1 to 4, 1919. A time-table of meetings and programs of the Chemical and Metals Sections will be published in the next issue. During the week of the Congress, the people of Cleveland will endeavor to excel the record established by St. Louis in its "Safety Week" last year. The goal is *no accident* in the week.

Talc and Soapstone Producers' Association

A meeting of all the talc producers of the United States, called by W. C. Boswell, president of the Harford Talc Co., Baltimore, Maryland, was held at the offices of the American Protective Tariff League, 339 Broadway, New York City, on Aug. 12, 1919, when the advisability of forming an association of the talc producers of the United States was decided upon. The protective tariff situation was also discussed.

The following representatives of the leading companies were present:

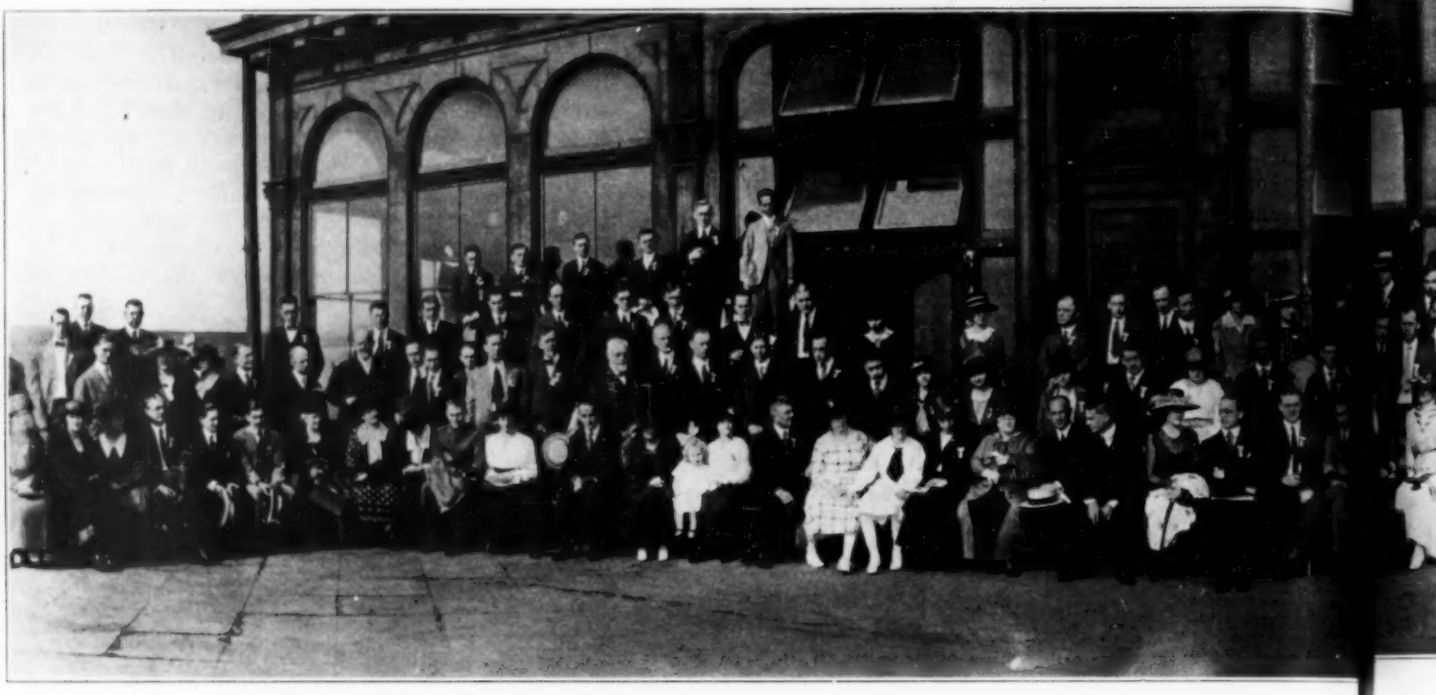
W. C. Boswell, Baltimore, Md., president Harford Talc Co.
H. B. Barling, Talc Products Co., 11 Pine St., New York, N. Y.
Dr. S. Westray Battle, Asheville, N. C., president Biltmore Talc Co.
Thomas P. Dean, Springfield, Mass., manager Vermont Talc Co.
Michael Doyle, 44 Park Row, New York, president International Pulp Co.
R. W. Glendinning, Los Angeles, Cal., general manager Pacific Coast Talc Co.
Raymond Bardeen Ladoo, U. S. Bureau of Mines, Washington, D. C.
John S. Moore, Johnson, Vt., treasurer American Mineral Co.
R. L. Rutzler, Charlotte, N. C., Oliver Quartz Co., industrial minerals.
W. Edward Seybel, 280 Madison Ave., New York, N. Y., Uniform Fibrous Talc Co.
Frederick Green, Easton, Pa., John O. Wagener & Co., mineral pulp, talc and silicate.
C. J. Zimmermann, New York City, president St. Lawrence Talc Co., Inc.
T. S. S. Predmore, Kinsey, N. C., general manager Alba Mineral Co.
Anglo-American Talc Co., 82 Beaver St., New York City.
J. T. Smith, Waterbury, Vt., manager Magnesia Talc Co.

Seven other conpanies reported by telegram, letter or by proxy, so that probably 90 per cent of the talc production of the country was represented. After discussing the tariff question, the motion to form an association was carried, a committee on organization appointed to draw up a constitution, and the following permanent officers were elected: President, Freeland Jewett (president Eastern Talc); vice-president, W. E. Seybel, and secretary-treasurer, R. B. Ladoo.

The Association of Talc and Soapstone Producers agreed upon at this meeting is the first and only one of its kind in this country. The objects of the association will be the betterment of processes and methods used in the mining or quarrying, and treatment for market of talc and soapstone; technical research into their physical and chemical properties looking toward the discovery of new uses and expansion of markets, and mutual exchange of technical, statistical and market information, expansion of markets through educational advertising, stabilization of markets and prices toward standardization of grades and tests, and the adoption of an efficient cost-keeping method. These objects have not been officially adopted by the producers, but probably many or most of them will eventually form a part of the constitution.

Metallography of Aluminum Ingot—Errata

In the article on the above subject in our issue for Sept. 1, pages 229-234, two unfortunate typographical errors were made which require correction. On page 229, paragraph 2, line 8, the text should read "relatively thick amorphous surface layer is highly *undesirable*." On page 232, the illustrations of Figs. 23, 24 and 25 should be inverted in order to conform to the description.



Philadelphia Meeting, American Chemical Society

Report of Council Meeting, General Addresses, Dye Section and Division of Industrial Chemists and Chemical Engineers—Society Protests Against Subordination of Chemical Warfare Service—Record Attendance — Over 250 Papers Read at Divisions

THE 58th meeting of the American Chemical Society during the first week in September at Philadelphia was introduced, as usual, by a meeting of the council of the Society. This took place at the Hotel Bellevue-Stratford on Tuesday afternoon, Sept. 2, with President W. H. NICHOLS in the chair. Ninety-seven councillors were present. The editors of the Society's various periodicals were all re-elected, as was also Secretary PARSONS. The name of the Division of Industrial Chemists and Chemical Engineers was changed to the Division of Industrial and Engineering Chemistry. It was determined to hold the next Spring meeting at St. Louis and the annual meeting at Chicago.

Dr. B. C. HESSE was chosen to succeed himself as councillor at large. There are two such councillors at large who, with the president, the two last presidents and the secretary, constitute the advisory committee; a committee that has been in existence only two or three years, but which has been found of great help and convenience in the administration of the Society's affairs.

It was provided that sections of the Society may have associate members who shall have no voting privileges but shall pay not less than $2 annually. The main purpose of this is to provide for the organization of bodies of men interested in some special field of chemistry which may be more or less localized.

Professor WASHBURN reported on the interallied Chemical Conference, in Paris and London. It is planned to provide for a continuation of International Congresses of Applied Chemistry under the auspices of the interallied body, but no date has been fixed upon as yet. The next meeting is to be held in Italy in 1920.

In regard to the committee on spelling, nomenclature and pronunciation it was resolved to ask the British chemical societies to co-operate. Both Englishmen and Americans will probably follow their national fancies in regard to old words, but there's no reason why they should not unite on new ones, more particularly in scientific nomenclature. It is very important that all English-speaking peoples should understand one another in this respect.

The leading feature discussed was in relation to the proposed bill (S. No. 2715) for the reorganization of the Army. A recommendation has been made by the Chief of Staff, General Peyton C. March, and the Secretary of War whereby it is provided that what is left of the Chemical Warfare Service shall be turned over to the Corps of Engineers. In effect it legislates chemically trained men out of control of the chemical work of the Army and it was held that the matter is too important even to respect West Point traditions. The following telegram was sent to Senator Wadsworth, chairman of the Senate Committee on Military Affairs:

> The American Chemical Society, of a membership of over 13,500 American chemists, today by its authorized representatives unanimously adopted the following:
>
> Whereas the recent war has clearly demonstrated that the advancement of science, through competently directed research in military problems, is indispensable to the security of the nation, and
>
> Whereas the bill recently introduced into Congress, Senate 2715, 66th Congress, by the General Staff of the Army, providing for universal military service and the reorganization of the Army, is of such scope and effect as to impede inevitably the development of all technical and scientific work of the Army by placing

it under the absolute control and direction of purely military officers who do not have the requisite scientific knowledge, and

Whereas an organization so constituted could not function efficiently, and in time of stress would prove to be an element of fatal weakness and could never hope to attract to itself other scientific and technical experts without whose aid modern warfare cannot be successfully conducted; now, therefore, be it

Resolved, That the American Chemical Society emphatically protests against this or any other bill which does not provide for commissioning staff officers in the corps and departments in which they are to serve, and which does not accord to the technical men the same recognition and opportunity throughout every grade and department of the Army as are accorded to the men trained for a military career only.

We have written so much in favor of this very attitude that we take pleasure in confirming it. It has nothing to do with urging gas warfare upon military authorities, but it does urge upon the Government the necessity of being prepared against it, and the only way to do this in regard to chemical problems is to have it done by chemists in a chemical division and under the supervision of chemists rather than of engineers.

The Council was entertained at dinner by the Philadelphia and Delaware Sections.

The General Meeting

The general meeting of the Society was called to order Wednesday, Sept. 3, at 10 o'clock by Chairman Miner, who after a few words of welcome introduced the Hon. Joseph S. McLoughlin, Director of Supplies of the City of Philadelphia, who spoke on behalf of the city. To this President Nichols responded in appreciation and introduced the Hon. Newton D. Baker, Secretary of War.

Secretary Baker said that of the 17,000 chemists of the United States one-third had been in uniform in the Government service and one-third had been engaged in war industries. He doubted if any profession had contributed more to military service or to our national success in the war than the chemists. He outlined the plans for the future of the Army. As an instance of the requirements of war he related the fact that to support a 3-in. gun with ten men at the front there is needed a factory with 300 operatives. The proposed law was not dealt with in detail, in fact the question of disposal of the Chemical Corps was hardly touched upon except for the fact that it is evident in the mind of Secretary Baker that ample provision is to be made to maintain scientific standards. We understand, however, that the Chief of the Engineers does not want the Chemical Division and the former heads of the Chemical Divisions have expressed themselves against the proposed law in its original shape. It may be that the Honorable Secretary in time will see over the heads of his staff officers and realize that a West Point man with all the responsibilities for canal and river and harbor improvements is no more peculiarly equipped to direct chemical research than he is to direct medical research. The new plan for the Army provides that there shall be a great educational institution, taking young men on to serve for a few years and sending them back to civil life well equipped with a craft. They plan to build a vast engineering school to include chemical as well as other branches of engineering and they expect to maintain a great research establishment to which the leading men of the country are to be invited to work and to exchange views with military men. The address was very appealing and masterful and contained many interesting facts. For instance, there are from 9 to 10 million men, young men, dead from the war, and its cost is 2 million million dollars, whereas all the property of the U. S. is valued at 186 thousand million dollars. There was a lower percentage of suicide, insanity or crime in the U. S. Army than in any other army or any known similar number of civilians.

The Secretary of War received the sincere applause and appreciation of all present, except in regard to that feature of his Army bill that seems defective in its provision for chemical research.

Admiral Ralph Earle, Chief of Ordnance, U. S. N., followed the Secretary of War and gave a full account of the use of explosives by the Navy. What is now needed is a smokeless powder that is not accompanied by a blinding flash when heavy charges are delivered.

Dr. H. J. Wheeler spoke on "Some Problems and

Methods in Agricultural Research." The address was in part historical in regard to agricultural chemistry in this country, but a number of present problems were outlined. He called, for instance, for research in regard to waste plants and waste plant products. There is promise in the utilization of milkweed, and, again, it is possible that values may be found for the Southern water hyacinth, which grows with extraordinary vigor. There is need for further research in regard to the chemical effect upon soils of lime, for instance, and in regard to the causes of acid conditions. Leadings are already provided for in these respects. Thus liming has been found to be detrimental under certain conditions and occasionally to incite plant diseases. In Hawaii the presence of an excess of manganese prevented the absorption of iron and the consequent production of chlorophyll, which was overcome by treating the leaves with a solution of iron. Only this year it was discovered that potash from Searles Lake frequently had a toxic effect which was found to be due to the presence of borax. More research is needed as to the effect of boron and borax upon vegetable life. Occasionally it appears that well-drained upland soils become acid, and Hartwell and Temper of Rhode Island have shown that often the toxic effect is not due to acidity but rather to the formation of aluminum sulphate. Sometimes, too, aluminum nitrate is formed, and that also acts as a poison. Study is needed as to the effects upon all kinds of plants of aluminum compounds and the lower oxides of iron.

The Department of Agriculture has found a large number of organic compounds in the soil which are deleterious in their nature. For instance, leachings of soil in which grass grows have been found injurious to many kinds of trees. One of the difficulties in regard to agricultural research is that the salaries paid to men of wide learning and experience are less than those paid for common labor.

Professor EARLE B. PHELPS spoke of "Stream Pollution and Its Relation to Chemical Industries." He believed that the drafting of legislation in regard to stream pollution should be in the hands of an intelligent board such as the River Board of Great Britain, and recommended that the subject be placed under Federal control.

BUILDING OF ATOMS AND THE PERIODIC SYSTEM

Professor W. D. HARKINS of the University of Chicago delivered a very interesting address to a capacity audience on "The Building of Atoms and the Periodic System." His theory in regard to the constitution of atoms has been published from time to time chiefly in the *Journal of the American Chemical Society*, but a number of new and very interesting points were brought out. Professor Harkins postulates that the helium atom is the product of combination of hydrogen atoms and that other elements are either combinations of helium atoms —which are the even numbers—while those having odd numbers are combinations or rather amalgamations of helium atoms with those of hydrogen. Elements of even number are much more prevalent than those which are odd. Differences of the atomic weights of elements of even number of approximate multiples of 4 are offered in confirmation. Still another confirmation is the successful experiment of Sir Ernest Rutherford, lately achieved, whereby he shot alpha particles at great speed into a glass tube containing nitrogen. The walls of the tube were sufficient to bring the particles to a standstill. Nitrogen being an odd element (number 7) is held to be made up of three helium atoms and two of hydrogen. The impact of the alpha particles which, being positively charged, may serve as nuclei of atoms, disintegrated the nitrogen so that a quantity of hydrogen was found in the tube.

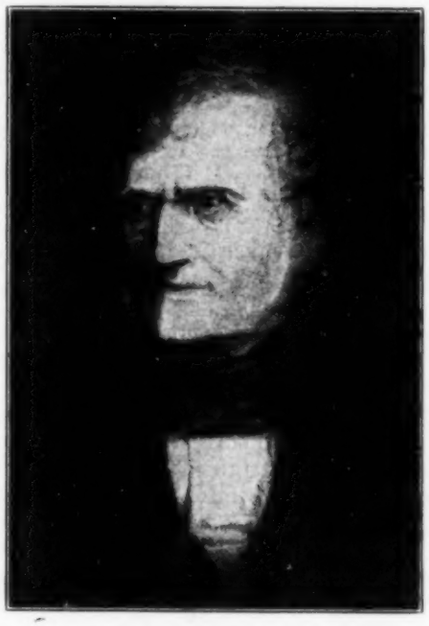
Mr. ROBERT R. FISHCELIS followed with a short paper on "The Chemical Laboratory as a Publicity Factor."

Social Features

The smoker was one of the best ever held by the Society and the entertainment provided was at once instructive and amusing. The singing was led by a song leader of the War Camp Community Service, and the songs, both originals and parodies, were unusually good. The reader can imagine, for instance, what an excellent parody on "Smiles" can be made by a chemist who is familiar with "smells."

One of the features of the smoker was a one-act play portraying an early chemists' meeting in the cellar laboratory of Robert Hare, Jr. at the time when Dr. Joseph Priestly came to Philadelphia. Not the least instructive feature of the smoker was a series of animated mechanical films by the Bray Studios.

The banquet on Friday night was a brilliant affair. Dr. Harry F. Keller acted as toast-master and introduced Dr. Edgar F. Smith, Provost of the University of Pennsylvania, who responded with a few brief references to the life and work of Robert Hare, an early



ROBERT HARE (1781-1858)

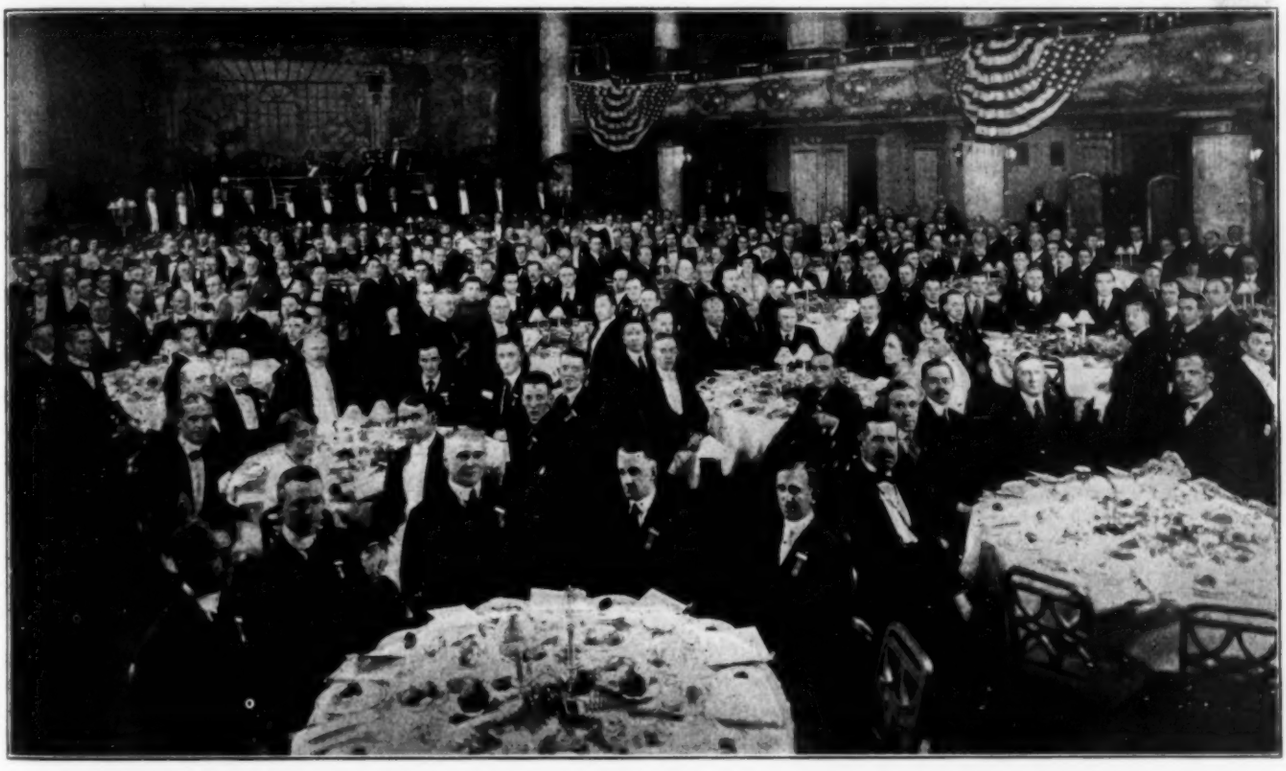
Philadelphia chemist. Following Dr. Smith's remarks each one present was given a steel engraving of Robert Hare, a copy of which is reproduced with this report.

Mr. Ellwood Hendrick, consulting editor of CHEMICAL & METALLURGICAL ENGINEERING, responded to the toast "The Chemist of the Future" and emphasized the need which the chemist has of someone in his profession to speak with the voice of authority. Following him the Hon. Edward E. Beidleman, Lieutenant-Governor of Pennsylvania, spoke on some phases of the present industrial conditions, saying that we must quit playing to the galleries on political issues, study civic problems

and increase production. Dr. Harlan S. Miner, presiding officer of the Philadephia Section, responded for the Section and told something of its work. Mr. Edward James Cattell, Philadelphia Statistician, made one of his characteristic humorous speeches. He was followed by Dr. Charles L. Reese, the presiding officer of the Delaware Section, who told of this infant organization which has over 400 members.

The program of the evening was closed by speeches from the only surviving charter members of the American Chemical Society, Dr. Charles F. Chandler and Dr. William H. Nichols. The latter suggested that one of our industrial troubles is due to the high cost of loafing and that a suitable remedy would be to stop loafing and substitute efficiency in our industrial life.

The all-day boat ride on the Delaware River, tendered by the Delaware Section, afforded an excellent opportunity for making acquaintances and talking over technical problems. The boat left Philadelphia at 9:45 A.M. and made a round trip to Deep Water Point. This afforded an opportunity to gain an idea of the extent of the chemical industries along the waterfront.



ANNUAL BANQUET, AMERICAN CHEMICAL SOCIETY, SEPT. 5, 1919, AT BELLEVUE-STRATFORD, PHILADELPHIA

A stop was made at Hog Island, where the *Sinsinawa* was launched. A complimentary box lunch was served on the boat.

Entertainment for the visiting ladies comprised several luncheons, automobile rides, a theater party, and an organ recital. The ladies also attended the banquet and river excursion.

The local Section is to be commended for its support of a daily issue of the *Catalyst*, which is the official bulletin of the Philadelphia and Delaware Sections. This contained registration lists, reports of meetings, announcements of programs, and last-minute information on convention details. This excellent feature of the meeting was in charge of the editors, Sydney Davis, Robert P. Fischelis and F. C. Zeisberg.

Presidential Address—Research and Application*

By Dr. William H. Nichols

For nearly half a century, it has been the custom in this Society to give its president every year "his day in court," and in conformity therewith many brilliant addresses have been delivered, and almost every conceivable subject has been discussed. It is therefore becoming more and more difficult for the incumbent to select a theme which shall have the merit of novelty, unless, perchance, he is himself working in the laboratory, and can bring forth some new and shining example of the progress of his science. I have not the good fortune to be so situated, and I must perforce satisfy myself with some other line of procedure in the hope that even in a discussion of old and well-known facts, some new light may be thrown, which will not be altogether without value. I have therefore selected for my subject, "Research and Application."

Research in the distant past was the privilege of the few. In chemistry, during the Middle Ages, the alchemists were practically the only ones pursuing it, and they in secret, and not always from the highest of motives. Working by themselves, as they did, they had not the great advantage of meeting and discussing with others similarly engaged, and using their progress and mistakes to intensify their own increase in knowledge. Thus it has come about that the science of chemistry is little more than a century old, and its tremendous advances only a few decades. The first chemical society in the world was born in Philadelphia in 1793, and yet the real advances have been made since the formation of this Society in 1876. Since that time, however, the advance in knowledge has been startling, not alone in this country, of course, but in all civilized countries.

*Abstract from the paper read before the American Chemical Society, Sept. 4, 1919.

It is not boasting to say, however, that during all that time, the progress in this country has been in nowise behind that of the best anywhere, which our public is at last beginning to recognize. Particularly during the trying period of the war, when vast and new problems were suddenly thrust upon them, the work of our chemists has been beyond praise.

At the foundation of all this advance, research is firmly imbedded.

No one can deny that there have been accidental discoveries, some of great moment; but this has not been and will not be a safe dependence. Accidental discoveries are not to be relied on, of course, although they are not to be scorned. In chemistry the accidental good fortunes have usually come to those who were really seeking, although possibly for something far different, but, note this, they were usually made by men qualified to recognize an important discovery when it flashed across their vision.

Research, of course, is not of necessity to result in invention. It may in that respect terminate in a culde-sac, from which, with present knowledge, there is no egress, or what more frequently happens, it may lead to a line of reasoning, which in time leads to another, and so on, until suddenly a bright light illumines the way, and a goal of the greatest possible importance is attained. Many instances illustrative of this will occur to you.

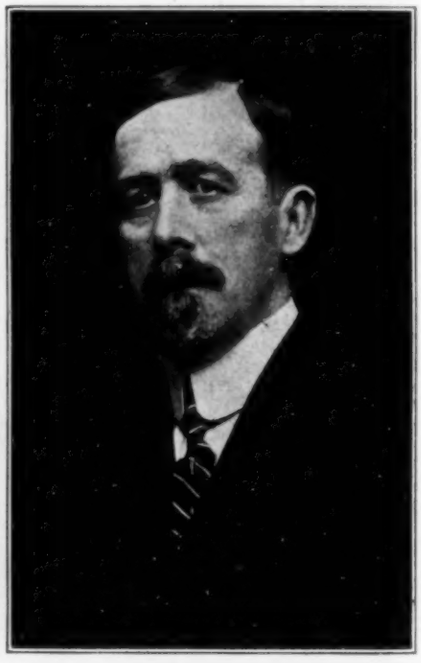
True research must be intentional and intensive. We must have imagination, it is true, but we must have more than that. There must be the foundation of sound education, and the ability to extend it to embrace new and unexpected knowledge, and apply this in turn as we progress upward.

To fit a man for research in chemistry or any other science, many things must be accomplished before the candidate is ready to take his first advanced step. Many methods of procedure have been suggested, and some heat of argument generated; but all agree that education which produces real practical knowledge is absolutely essential. All agree, also, that the person to be prepared must be a likely subject; and that energy and time should not be wasted on those who do not show that they possess certain necessary qualifications. I think that it will also be generally admitted that the teacher himself should not only have great attainments, but must also possess the rare quality of being able to transmit knowledge in such a way that it will be truly absorbed by the pupil and form part of him. One of the greatest mathematicians I have ever known was about the poorest teacher. He knew but could not impart. The future of the world, therefore, depends in a very large degree, on the teacher in the school and on the professor in the college. They have an opportunity to mold the world, which many of them thoroughly appreciate. Alas, in most instances, the consciousness of work well done is about their only reward. Some day, and I hope not a very distant one, it will be generally recognized that, like other laborers, they are worthy of their hire, and their compensation will more nearly approximate the value of the work done. When that happy day arrives, they may experience a little less of the satisfaction of sacrifice, but they will have other comforts and hopes which will more than make this up to them and to their families. Like others before me, I advise the people of this country that they can make no better investment than one liberal enough to cause the teaching profession to attract not only those whose high sense of duty leads them to embrace it at a sacrifice, but also those who cannot afford to make the sacrifice, however anxious they may be to do so. Men preparing for research must have the best men in the country to guide them, and it is not fair to expect these men, as so many have done in the past, to live the narrowing life of poverty. Neither is it wise.

There are a few foundations specifically provided for chemical research, such as the Warren Fund of the

CHARLES L. PARSONS
Secretary American Chemical Society

WILLIAM H. NICHOLS
President American Chemical Society



HARLAN S. MINER
Chairman Philadelphia Section

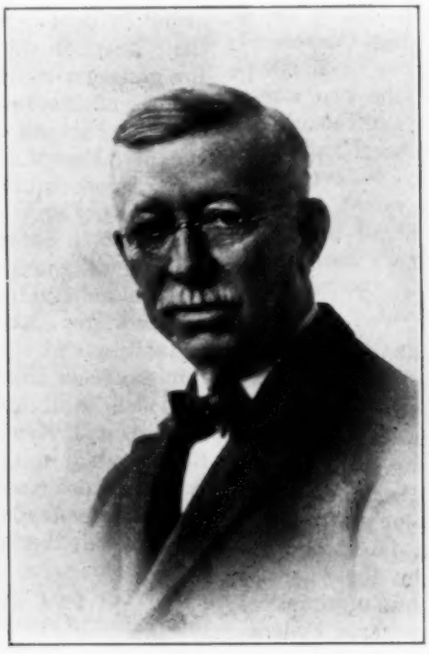
American Academy of Arts and Sciences, the C. M. Warren Fund of Harvard University, and the Wolcott-Gibbs Fund of the National Academy of Sciences. There are a number of foundations for promoting research generally which have included chemical research within their fields, such as the Bache Fund of the National Academy of Sciences and the Elizabeth Thompson Science Fund. The Rockefeller Institute for Medical Research fosters chemical research contributory to its main object, the Carnegie Institution of Washington supports chemical research in its general policy of advancing knowledge through research. The newest of all is the fund recently placed at the disposal of the National Research Council for stimulating chemical research. There is need for many more foundations if we are to keep pace with the rapid strides of civilization, or better still, to determine the direction they will take.

The importance of research is being more and more recognized and understood by the public. One of the most encouraging evidences of this is shown in the preamble and resolution adopted recently by the American Federation of Labor at Atlantic City, indicating, as these do, a clear appreciation by that great association of how much we all depend on what science will disclose to ameliorate the conditions of the future. It is well worth while to read these in full here. They are as follows:

> Whereas scientific research and the technical application of results of research form a fundamental basis upon which the development of our industries, manufacturing, agriculture, mining, and others must rest; and
>
> Whereas the productivity of industry is greatly increased by the technical application of the results of scientific research in physics, chemistry, biology and geology, in engineering and agriculture, and in the related sciences; and the health and well-being not only of the workers but of the whole population as well, are dependent upon advances in medicine and sanitation; so that the value of scientific advancement to the welfare of the nation is many times greater than the cost of the necessary research; and
>
> Whereas the increased productivity of industry resulting from scientific research is a most potent factor in the ever-increasing struggle of the workers to raise their standards of living, and the importance of this factor must steadily increase, since there is a limit beyond which the average standard of living of the whole population cannot progress by the usual methods of re-adjustment, which limit can only be raised by research and the utilization of the results of research in industry; and
>
> Whereas there are numerous important and pressing problems of administration and regulation now faced by Federal, State and local governments, the wise solution of which depends upon scientific and technical research; and
>
> Whereas the war has brought home to all the nations engaged in it the overwhelming importance of science and technology to national welfare, whether in war or in peace, and not only is private initiative attempting to organize far-reaching research in these fields on a national scale, but in several countries governmental participation and support of such undertaking are already active; therefore be it
>
> *Resolved*, By the American Federation of Labor in convention assembled, that a broad program of scientific and technical research is of major importance to the national welfare and should be fostered in every way by the Federal Government, and that the activities of the Government itself in such research should be adequately and generously supported in order that the work may be greatly strengthened and extended; and the secretary of the Federation is instructed to transmit copies of this resolution to the President of the United States, to the President pro tempore of the Senate, and to the Speaker of the House of Representatives.

I hope and believe that this matter, coming as it does from a new direction, will be most seriously considered by the proper authorities—not that it has not already been well understood in Washington, but that renewed interest may be taken and even more liberal appropriations granted. The Federation resolution urges that "a broad program of scientific and technical research is of major importance to the national welfare." Good! Now that everybody is agreed, how was it possible

BERNHARD C. HESSE
Councillor at Large



EDGAR F. SMITH
Provost, University of Pennsylvania

GEORGE D. ROSENGARTEN
Chairman Program Committee

that for so long a time this belief was held by so few, and these composed almost entirely of men of science? The question, therefore, is squarely before the country, and the urgency of it thoroughly appreciated by those who have the most to gain by it; namely, the workers on whose efficiency so much depends. Now this opens the way to a scientific solution of vital questions about which there has been such fundamental differences of opinion, based largely on what may be called the point of view.

Capital and Labor

People have divided themselves into classes—a very dangerous course—and many, a very great many, have actually believed that there must of necessity be a deeply rooted difference between capital and labor, and that the true interests of either were entirely apart from those of the other. Many have held that labor is a commodity which it was to their best interest to get the most of for the least money, while many others believed that labor was the sole source of all wealth, and that the fewer hours worked, and the smaller the output of those hours, the better it would be, somehow or another, for the laboring classes. I have cited the extreme views for purpose of illustration, realizing that somewhere between the two would be found the great body of all reasonable and thoughtful men. We may leave out of consideration here that ultra-extreme class who teach, whether they believe it or not, that the true interests of labor would be best served by sabotage and syndicalism, and all the other fantastic notions which have of late years been more or less in evidence, and liable to catch the unwary. To these, research presents no attractions.

Co-ordination of Study and Practice

Now I am going to venture to suggest to the workingman who is earnestly desirous of bettering his own and his family's condition that there are a good many sciences besides chemistry and the engineering and abstract sciences in general. Some of these he is better able to study and practice than any one else. Many of the fundamental truths concerning labor and its conditions would never be discovered by the scientist per se, because he has not had the benefit of practical preparation. Let our friends of the American Federation of Labor not be content with what the Government can do in the line of their resolution, good as it has been and will be, but let them start a carefully planned series of researches themselves, and follow them up until the truth stands revealed. They can depend upon the assistance of this great Society. The employers of labor have been doing this for years, singly and in groups, seeking the same end. The shining goal of all research is the truth, the whole truth, and nothing but the truth. Thus, starting from different angles, with fairness and thoroughness, the various so-called interests will arrive at the same truth, for there can be only one truth concerning any question. Thus will it come to pass that capital and labor will discover that the true interest of one is the true interest of all, and instead of bickerings and suspicions we will have that cordial co-operation which is absolutely essential if we would get the best out of this good old world.

Research leads to discovery. Discovery to invention. Invention—no one knows where. Applied and supervised by those prepared for the task, the strides of progress will be long, and the benefit to the human race in proportion.

Papers Read Before the Divisions

About 250 papers were given before the ten divisions, so that the best those who attended the meeting could hope to do was to hear about one-tenth of them.

A report on the Division of Industrial Chemists and Chemical Engineers and the Dye Section is given below. The Rubber Division will be reported in a following issue. A few notes taken from papers of other divisions are given, but these were not made complete, as many of them will be published in full in the near future.

Uses for Sharks

Allen Rogers of Pratt Institute in an interesting paper before the Agricultural and Food Division on the utilization of sharks drew attention to the importance of overcoming modern prejudices against the shark and stated that from time immemorial the shark has been considered as an enemy to man and as a scavenger of the sea. It has been pictured as the cannibal of the deep, and in fiction has been painted as the vulture which lurks about the ill-fated ship in order to devour the unfortunate who may have met their death in the gale or on the reef. We, therefore, for generations have cherished an antipathy for this animal of the sea and have been very willing to accept as fact all of these stories, never stopping to consider that perhaps after all the shark might have a few good points in his favor.

The Bureau of Fisheries for several years has endeavored to interest the people of this country in the use of shark meat as an edible product, with a certain amount of success. In fact, that species of shark known as dogfish is being canned in large quantities and sold under the name of grayfish. Certain fisheries on the New England coast are removing the head, tail and fins and selling the product in Boston and New York as deep sea swordfish. In Boston also shark meat is being sold as such to the Italian trade, who appreciate its food value and enjoy its delicate flavor. Why then should we not take a lesson from the Italians and acquire the shark-eating habit?

For the past five or six years Dr. Rogers has been interested in developing a method for converting shark skins into a merchantable leather. As a result of this work several processes have been devised which have been assigned to the Ocean Leather Co., operating fisheries at Morehead City, N. C., and Fort Myers, Fla. This concern alone expects to get up to a catch of 1000 fish daily, although at present it is not taking this number. The skins are now being manufactured into leather, the livers rendered for their oil and the flesh converted into fertilizer stock. It is estimated also that at least 1000 sharks can be secured daily from the fishermen handling food fish, who at present simply kill the sharks getting into their nets and throw them back into the water. By this wasteful procedure on the part of the fishermen at least 1000 sharks daily are destroyed along the Atlantic coast. Thus not only is the skin lost to the leather trade, not only is the liver oil discarded, not only is a large amount of fertilizer material made unavailable; but at least 50 per cent of the weight of shark which would be fit for human consumption goes to waste.

A conservative estimate based on the above figures indicates that for a catch of 2000 sharks daily, at an average weight of 200 lb., there would be 400,000 lb.

of fish. As at least 50 per cent could be used for human consumption, we would have 200,000 lb. daily, or 73,000,000 lb. annually. Assuming that the market price could be set at 10c. we have a saving of $7,300,000.

The question of supply is one that is constantly being asked. From personal observations and from those who are most familiar with the subject, it seems evident that the supply is inexhaustible. Another question is often raised as to the best method to prepare the flesh for market. The answer is cold storage. This method, however, may not always be practical in isolated fishing stations. Recourse must then be made to salting, smoking or drying. The fresh meat, however, is the most delicious, and when boiled, broiled or baked furnishes a white flaky food closely resembling halibut or swordfish.

A source of food supply so extensive warrants our most careful consideration, and it is hoped that the time is not far off when we may overcome our prejudice and take advantage of nature's abundant supply.

Greater Efficiency Needed in the Chamber Process

Andrew M. Fairlie of Atlanta in his paper before the Fertilizer Division on the conservation of saltpeter in the chamber process stated that 14 per cent of the nitric acid in the Gay-Lussac towers was lost per cycle, and in connection with the prevalent protest against the high cost of food, means for conserving nitrate of soda in the manufacture of sulphuric acid has twofold interest.

The lowest possible consumption of nitrate of soda in the manufacture of suphuric acid means low cost for producing the acid, and, as sulphuric acid is the principal item in the cost of making acid phosphate, cheaper sulphuric acid should result in cheaper phosphate, and cheaper phosphate should result in cheaper food.

Nitrate of soda is itself an important ingredient of fertilizer, and any decrease in the consumption of nitrate for making acid should react in favor of a decreased demand, and so of a lower price, for nitrate of soda.

The various methods of introducing nitrogen compounds into the acid-making process were reviewed, and the methods in common use for controlling the chamber process briefly described. Attention is directed to the gradual extension of the analytical method for chamber-process control, and to the improved results attained where this result has been adopted. The Gay-Lussac tower, as a means of recovering the nitrogen compounds, is not an ideal or yet an efficient piece of apparatus, and the need exists for either an improved type of Gay-Lussac tower, an auxiliary to the Gay-Lussac tower, or a substitute for that tower, capable of effecting a higher percentage of nitrogen recovery.

Slide Rule for Calculating SO Conversion

F. C. Blake of Wilmington in his paper before the Physical and Inorganic Division on the construction of special slide rules for chemical calculations gave a description of two rules. The one on SO_2 conversion to SO_3 should be in general use in sulphuric acid works.

In general, if an equation can be written in the form

$$f(x) = f(y), f(z)$$

a slide rule may be constructed so that the value of any variable may be found if the others are known. As a simple illustration, consider the computation of conversion in the contact process for the manufacture of sulphuric acid. Let

a = per cent by volume of SO_2 in entrance gas

b = per cent by volume of SO_2 in exit gas

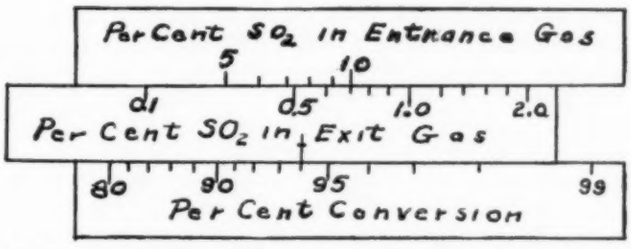
c = per cent conversion = per cent of SO_2 converted to SO_3.

These quantities are related by the equation

$$c = \frac{10000(a - b)}{100a - \frac{3ab}{2}}$$

This form of equation is not suitable for the construction of a slide rule, but it may be rewritten as

$$1 - \frac{c}{100} = \left(\frac{100}{a} - \frac{3}{2}\right) \div \left(\frac{100}{b} - \frac{3}{2}\right)$$



SO_2-SO_3 RULE SET, 10 PER CENT ENTRANCE, 0.7 PER CENT EXIT EQUALS 94 PER CENT CONVERSION

The slide rule scales for the solution of this equation are in the accompanying figure. The upper scale is laid off proportionally to log $\left(\frac{100}{a} - \frac{3}{2}\right)$ the slider to log $\left(\frac{100}{b} - \frac{3}{2}\right)$ and the lower scale to log $\left(1 - \frac{c}{100}\right)$. These scales are laid off from right to left so that the marked values a, b and c will increase from left to right, as this is the most natural method of reading scales. The proper values of SO_2 in burner gas and exit gas are set together and the conversion read opposite the arrow. The zero point (i.e., log 1) of the lower scale is moved to the left relative to the upper one to make the rule more compact and the arrow displaced the same distance to give the correct reading.

The Dye Section

The meeting of the Dye Section was so well attended that it was necessary to move from the little "Green Room" set apart for it to one of the large restaurant rooms on the main floor. Dr. Charles L. Reese, the chairman of the Section, presided. In his introductory remarks he said that some two or more years ago he told the American Cotton Manufacturers Association what American chemists could do for them, and he was now ready and willing to review what they had done for them in the meantime. There is some $100,000,000 invested in the American dye industry, and it has taken the courage of conviction to make these ventures. Every new industry has high production costs in the beginning and manufacturing units have to be made small to avoid extraordinary losses. Manufacturing costs, however, are improving. He explained the origin and workings of the Chemical Foundation, discussed the licensing system as developed in England and predicted that within another year's time the dye industry would be much further advanced. Indanthrene dyes (a type of the much needed fast cotton vat dyes) are

being produced today and he believes that in six months the consumer will have all of these that he desires. This belief was later confirmed by Dr. GRINNELL JONES, who said he had seen factories at work producing vat dyes and large works already built and ready to begin. There is more indigo made in this country today than was imported before the war.

Major T. H. SILL followed with an address on "The Present Condition of the German Dye Plants." In February and March of this year Major Sill inspected the leading German dye plants to observe what they had done in war. He was under the impression that they were in pretty bad shape, but soon found them to be in perfect operating condition, except in a few minor details. They retain their complete forces, and owing to the stress of war, the plants have been enlarged. They are operating on only about 10 per cent of a peace basis, but they keep their labor occupied in cleaning and polishing and away from bolshevist agitation. Result is everything is remarkably cleaned up. At the time their only shortage was zinc dust, pyrites and chrome ore, which they can probably get now. They were also short of lubricating oils.

The best and most modern of the German works is the Bayer establishment at Leverkusen, opposite Cologne. Their offices and clubs for workmen are almost palaces and the place is nearly a city by itself. One of the first persons he met was Prof. Duisberg, their managing director, who will be remembered by those who attended the Eighth International Congress of Applied Chemistry in New York in 1912 as providing a perfect specimen of German competence and boastfulness. The genial Dr. Duisberg assured Major Sill that as for the Bayer works, they were really such novices at the art of making poison gases that they could hardly be reckoned as a factor in it. The Major soon learned, however, that this same Bayer Co. had been leading producers of mustard, diphosgene, etc. The Bayer Co. has been making artificial rubber at the rate of 150 tons a month. The price has been high—30 to 40 marks per kilo—but this, it is believed, will soon be greatly reduced and the company expects to compete with natural rubber. Another very interesting development was the manufacture of 1000 tons per month of sulphuric acid from gypsum.

The establishment of Weiler ter Meer at Merdingen he found well kept up and that it had in 1918 erected a palatial clubhouse for its workingmen.

Kalle & Co. at Bieberich looked run down and delapidated, but the Hoechst works, formerly Meister Lucius & Brüning, had had a wonderful development, doubling their employees from 8,000 to 16,000 men. They were pioneers in making poison gases and oxidized vast amounts of ammonia to nitric acid. This concern is in excellent condition.

The Badische Aniline & Soda Fabrik at Ludwigshaven employs about 16,000 men, and it is older and more congested than the Bayer works. It has continued to make dyes during the war and it is said to have not only a large accumulation of dyes but still greater stores in the interior of Germany. A little further up the river is the $75,000,000 Haber process works of which the research laboratory alone cost over $1,000,000. Here and elsewhere in Germany there were some 650 tons of ammonia per day produced. The country has been producing more ammonium products than before the war.

Major Sill did not believe that the layout of the German plants was better than those of America, although in addition to the advantage of experience in technique they have certain features that are improvements over American practice. Among these he mentioned the habit of building water towers around chimneys and thus utilizing a good part of the heat; a better distribution of filter presses, a novel nitration system and remarkably high-grade lead fittings. On the other hand, they lack elevator and conveying machinery and there is a great deal of transportation of materials from plant to plant which would never do in this country.

These German plants, he said, owing to their equipment, their competent staffs of chemists and their chemical versatility, constitute the technical reason why there lie 38,000 of the flower of American youth dead in France, with a far greater number maimed. It was one of the directors of the Badische Aniline & Soda Fabrik who lately said: "We [Germans] need be in no terror as to the future of our dye industry. American textile manufacturers will not continue to pay high prices, and when the markets are open, so-called patriotism in that country will vanish like hoar-frost on a sunny Spring morning."

At this point Dr. Reese observed that while prices of American dyes might be higher for some time to come, the German product would have no advantage whatever as to quality.

Dr. J. MERRITT MATTHEWS gave a review of the dye situation.

We have discovered, he said, that the real secret of German success was to be patient in research and to carry research into the factory. A study of the dye census of 1918 shows that the American industry supplies a large proportion of the colors needed. The development has been somewhat one-sided, but this has been for economic reasons. In England they have brought out a good range of vat dyes and of true alizarine colors; on the other hand, the American development has been greater in azo and direct cotton colors, also in fuchsine and color lakes for paints and printing inks. Rating the American industry as 100 per cent, he thought the British coal-tar color industry will represent 50 to 75 per cent in comparison. France was like the rest of us before the war and expanded less for self-evident reasons. Since the armistice she has gone ahead, her chief accomplishment being the production of indigo. Other dyes are less important in quantity. The close relations with Switzerland are already shown in the establishment of a branch in France of the largest Swiss works, the Society of Chemical Industry of Basle. It is likely too that the French oversight of the Badische will provide for some French chemists some important hints as to technique. Japan is a newcomer in the industry and has but one really effective establishment. That country is making less headway than the others.

We must bear in mind that the world market for dyes is not capable of very great expansion. Before the war Germany supplied from 80 to 90 per cent of the world trade. The Germans can soon reach greater production than before, and they are ready to go ahead again. Great Britain has laid out plans to take care of its home and colonial markets. And it will. The capital invested is large and the British government has gone into the partnership. It is a foregone conclusion that

the British and Colonial markets will be withdrawn from the world's trade. And they will have a surplus to offer for the international demands.

In this country, Dr. Matthews figured, $60,000,000 to $80,000,000 has been invested in the industry. The capacity is large and it is growing. With proper encouragement from the Government he believes that in all events in a few years if not, as Dr. Reese believes, in a few months time, the gaps will be filled up. It can easily care for the American market and export the surplus.

France is resolved to develop, but it may use Switzerland in part and it may take dyes from Germany in part payment of indemnity. The Swiss have increased their coal-tar color industry threefold since the war and will probably rank next to Germany in efficiency and economy. So we shall have, competing for the world's market, Germany, Switzerland, the United States and England for certain and possibly France and Japan. Roughly, it may be divided as continental Europe 20 per cent, Great Britain 15 per cent, United States 12 per cent, Asiatic countries 45 per cent, South America 5 per cent, Africa 3 per cent. Only half of the world's markets are open, while productive capacity has increased threefold. Now, the salvation of the industry lies in intense research to develop uses for all by-products and raw and useful products from the same materials so that the making of dyes becomes incidental to the making of many other useful things.

Dr. GRINNELL JONES of the Tariff Commission discussed the progress of the dye industry as shown by the Commission's census of 1918. The production of benzene and toluene has far outstripped the needs of the color industry, being 52,000,000 gal. benzene and 14,000,000 gal. toluene in 1918. Five firms produced crude anthracene, but their joint product was less than 250,000 lb., which is not enough. The situation is improved. Carbazol was also first produced in 1918, but we are still short of carbazol products. A decrease is shown in the production of the easiest intermediates to make, but this is compensated for by the increase in more difficult intermediates and dyes made from them. This indicates an improvement in the kinds of dyes made. Another good feature is the decrease in the prices of dyes and intermediates despite increased costs of labor, construction and transportation. This means making steps toward a true competitive basis. Dr. Jones has seen a number of plants designed by German and Swiss chemists which were redesigned by American chemists to their great advantage in the economy of labor.

Mr. R. S. LUNT spoke of "The Quality of American Dyes," and declared that shipments are now running fully as close to standard as before the war.

Mr. H. A. LUBS reported a new series of indicators and Mr. H. D. GIBBS described the work of the color laboratory of the Bureau of Chemistry at Washington, D. C.

On Friday morning the Dye Section crowded the large dining room on the main floor of the Bellevue-Stratford. Dr. W. F. EDWARDS urged standardized tests for dyed goods in order to break down the prejudice against American-made dyes. Retailers, in order to avoid responsibility for the color quality of goods sold, declare that American dyes are not dependable and that their customers must take their chances in this respect. Now it is very easy to determine the color quality of cloth; just as easy as it is to make very simple steel tests, and the processes are inexpensive. The only thing required is an agreement upon standards, and it is to be hoped that the Dye Section of the Society will take the matter up and provide for this much needed achievement.

Dr. E. W. PIERCE of New York presented a very interesting historical paper on "The Application of Dyes." We shall only note that the reason why the dyeing of Tyrian purple remained a secret and that the dyers of it were social outcasts was because a putrefactive process was employed which rendered it next to impossible for anyone to go near the dye houses or to the men who worked in them.

One of the most interesting papers was presented by Mr. EDGAR T. WHERRY on "Crystallographic Identification of Five Isocyanines." He found that in the five instances mentioned, the identical substance might show a marked difference in the color of its crystals; that different batches of the same substance would vary from yellow to purple. This phenomenon, he said, was due to reflectional pleochroism, in which the color of reflected light varies according to the plane reflected to the axis of the crystal. Thus the color would range from yellow to purple as the crystalline habit developed one set of planes or another. This rare phenomenon explains the fact that a dye may vary in the color of its crystals while remaining the same in chemical structure and tinctorial effect.

Mr. W. H. WATKINS of the National Aniline & Chemical Co. presented a paper on "Observations on the Estimation of the Strength of Dyes." It was a contribution of great practical value, providing methods for adjusting differences between buyers and sellers.

Mr. E. K. STRACHEN of Buffalo, also connected with the National Aniline & Chemical Co., spoke on "The Application of Physical Chemistry Research on Dyes." This was of the sort to make our old-fashioned color chemists sit up and take notice. A number of very valuable curves were shown.

Division of Industrial Chemists and Chemical Engineers

The earnestness of endeavor of the members of this section and the successful work which they are thereby accomplishing was clearly demonstrated in the number and high character of the papers presented at this meeting. It seems truly marvelous that the wide field embraced should be so thoroughly covered in the short time allowed for the deliberations, and the result can only be attributed to the fact that each individual member, upheld by highly developed imagination, is following the ideal of benefit to the industry without thought of self. The direction of the work was carried on under Dr. H. S. MINER, chairman, with H. E. HOWE secretary. Two symposiums and 27 papers were presented. Abstracts of a few of these are given below.

Gas Masks in the Industries—A. C. FIELDNER. In order to promote the development of safe and suitable designs of gas masks of the Army type for industrial use, the Bureau of Mines has established a gas mask department at the Pittsburgh Experiment Station. The Bureau will co-operate with manufacturers of gas masks in approving them for use in the gases for which they are intended provided they pass the tests prescribed in Schedule 14. A 1000-cu.ft. gas chamber has been installed in which masks can be tested in various concentrations of any gas desired. Other equipments

for making mechanical and chemical tests are also provided.

Division of Industrial Research. National Research Council—H. E. HOWE. The speaker explained that this division is not a Government department but an organization with the purpose of developing research for the common welfare of the country's industries.

The Council will not itself maintain laboratories for conducting research, but will function to encourage research by men of the industry. It will accomplish this in making public the work done by others through the medium of pamphlets and data published in the columns of the American Chemical Society's journals.

The Value of Cost Accounting in Commercial Laboratories—WILLIAM W. CASWELL. Cost accounting systems, long considered an unnecessary frill and a burdensome evil, have come to be recognized as an important requirement in the conduct of general business institutions. Statistics show that of the 250,000 corporations doing business in the United States only 125,000 are making money, and that only 5 per cent of the total number have an adequate cost accounting organization. Investigation has shown the great value of this work, not as a means of record, but as a source of knowledge for the proper administration of the work.

The need applies equally in the commercial research laboratory. Here the question of raw materials and machinery accounts need not be considered, but rather the item of labor of chemist and department head is covered under direct expense, and burden or overhead under indirect expense. The cost embraces this direct expense plus the indirect, which includes the official salaries, etc. To this cost a fair percentage of profit must be added, in order to obtain price to be charged the client.

If this system is not used one job or one department will be supporting another, and an ultimate loss of money may result. Where so diversified a work is carried on as in this business the executive, to be successful, must have an accurate idea of what each department is doing. The various departments of a commercial laboratory ordinarily resolve themselves into analytical, research, paper pulp, textile, cement, oil and engineering laboratories.

An effective system must be simple and free from red tape. The executive must work with the accountant in establishing and carrying out the system with this thought in mind.

After the record has been carried on for a period of, say, one year, the data are then available for fixing prices to be charged for analyses. During this time the average costs may be obtained from working time required by different chemists on the same analysis. Future deviations from this average will serve to show up the weak and the strong operators, and awards may be given through praise or even a cash bonus. It is obvious that a skilled chemist saving the company money on each analysis is entitled to substantial reward. Efficiency is then increased by desire for this reward and the man develops a pride in his work.

A laboratory without a cost accounting system is like a ship without a rudder. The executive must know the details of his business. The object of this paper is to arouse the interest of each member in the development of his own business. Once installed he will ask himself, "How did I ever get along without it?"

The paper was commended highly by the members of the section and the author volunteered to help any member who would communicate with him, by giving the benefit of his own experience.

Modern Commercial Explosives—R. L. HILL. The processes of making the commercial explosives were given in outline. The explosive and non-explosive ingredients are made separately and then mixed under proper conditions. The well-known black blasting powder is still popular with the trade. The dynamites are classified as straight dynamite, straight gelatine dynamite, ammonia dynamite and ammonia gelatine dynamite.

The straight and straight gelatine dynamites under the old methods of manufacture are liable to freeze at temperatures as high as 50 deg. F. and the ammonium compound is substituted for the sodium and potassium in the production. Ammonium nitrate compounds are largely used in Europe, but the hygroscopic qualities make it hard to protect from deterioration in damp climates. The protection from this is usually taken care of by the use of a moisture-proof container.

Permissible explosives are used chiefly in coal mine blasting, where danger of ignition of mine gases exists. The substance is compounded with the view of having as little flash or fire with the detonation as possible. The explosion is not entirely devoid of flash, but the amount may be greatly reduced. The powder must have a large deficiency of oxygen, high amount of water content, as in $(NH_4)NO_3$, and be low in nitroglycerine.

The nitro-starches came into great demand during the war and make a good industrial explosive for some purposes. They have a high order of detonation.

The consumer of explosives is more critical of the product than in perhaps any other business. It is necessary to consider chemical properties from the time raw material arrives at the factory until the charge is planted by him. Careful chemical control is involved in every stage of manufacture. Testing galleries show proof of the finished product. Permissible limits of change or deterioration until put in use must be known. Specifications for the particular article desired should include strength, density, velocity of detonation, sensitiveness of the primer, consistency, water resistance, cold resistance and nature and volume of resulting gases.

Chemical Reagents Received by the Bureau of Chemistry During the War—H. E. BUC. The Bureau began testing samples sent in a great many years before the war and found the products satisfactory until about six years ago, when left-over chemicals began to come on the market. After 1915 the shipments became very unsatisfactory, about 150 analyses out of 1300 showing an excess of impurities. The labels on the bottles were inaccurate as to the contents.

In general the acids and alkalis were permissible and the soluble salts were acceptable, but not of a high degree of purity. The insoluble products were unfit for use.

Report on the Production of Synthetic Organic Chemicals in the Research Laboratory of the Eastman Kodak Co., 1918 and 1919—C. E. K. MEES. The work of commercial preparation of these compounds began in September, 1918, and has continued over a period of eleven months. Great help has been received from the chemists and manufacturers as well as the university laboratories, including the Universities of

Illinois, Missouri and Oklahoma, and the College of Forestry at Syracuse, N. Y. It is the desire of this organization to act as a clearing house for all this class of work. Five hundred and sixty chemicals were included in the plans and of these 348 were undertaken, with this laboratory working on 268 out of the latter quantity.

Chemicals of three degrees of purity were supplied to the trade, Eastman's Best, the highest grade; commercial grade, ordinary synthetic chemicals with impurities marked on the label; and technical chemicals. The last mentioned class was not made in the laboratory, but was purchased in commercial lots from the manufacturers and repacked in small quantities for users requiring it.

The financial statement for the period of 11 months of this work showed a loss of $17,397, of which $6000 is depreciation of stock caused by the difference in present market figures and the purchase prices with war-time inflation. As an example of the decreasing loss, the July figures show a total of $304—manufacturing loss. During this month there was $747 charged to depreciation and overhead expense. There is a current loss due to explosions incident to the experimental operations and for this reason a profit cannot be shown for several years to come.

A reduction of the loss might be effected by increased production, involving, however, a large outlay for apparatus. As now working this can be done only as demand for product develops. The field of activity could also be narrowed by dropping development work and confining efforts only to chemicals for which there is a paying demand.

The work is exceptionally dangerous and the risk unavoidable, as about 32 new preparations are started per month. New buildings are being erected to house the laboratory so as not to endanger the loss of the Eastman plant through fire or explosion. The author believes the ultimate success of the undertaking is assured if the products of the German chemists are not purchased.

Symposium on Refractories

Dr. MINER resigned the chair to A. V. BLEININGER, who called attention to the many undetermined factors in the manufacture and application of refractories. These materials entering into the construction of furnaces of all sorts must be not only resistant to heat but also to mechanical shocks, heavy pressure and the scouring action of materials under treatment. The paper, "Classification of Refractories," by G. H. BROWN was not presented but was said to contain a review of the different types from the high-grade flint clay brick, the silica and magnesite refractories down to the common fire clay brick.

Work of the Technical Department of the Refractories Manufacturers' Association—R. M. HOWE. During May, 1917, the Manufacturers' Association established a fellowship at the University of Pittsburgh for research work on refractories. A laboratory was equipped and tests commenced on fire brick. Since that time the personnel has increased from one to five investigators and over 50 companies have been served. The organization is self-supporting and its mode of operation is such as to prevent a monopoly of the service by any one company. Some tests have been made on magnesite and silica.

The work has embraced mining selections by drill cores, analyses of same, together with investigations of mixtures and blends made up of brick bats, bauxite, silica, etc. Among other factors considered were temperature operation, water content, abrasive qualities and physical strength. It was found that an increase of water content increased the strength of the brick. Method of manufacture and drying depends on type of clay as regards its contraction characteristics. Performance of brick under service is also a part of the work.

The Selection of Refractories for Industrial Furnaces—W. F. ROCHOW. The chemical composition of a refractory material is not so important as heretofore considered, especially in many cases where the temperature is not of sufficient height to reach the point required for chemical reaction between the walls of the furnace and the material being treated. It is often better to use an acid brick with a basic material, or vice versa. An example of this is the use of silica brick in the glass industry.

Silica brick is found to be 25 per cent better than fire clay for by-product coke ovens due to its high thermal conductivity, mechanical strength and high fusing point. A more uniform temperature is secured in muffles due to the high thermal conductivity. Thermal expansion of silica brick occurs between 230 and 500 deg. C. and the heat must be carefully applied through this range. It is practically eliminated after the first burning. The mechanical strength is good at high tempertures. In arch construction it is insulated with kieselguhr. Long service of a brick in open-hearth furnaces shows four distinct strata with the lime stratum carried to the center of the brick and away from the heat.

Magnesite brick is not strong at high temperatures, and in order to remedy this feature a soft steel band or casing is built around blocks of dead burned magnesite for such work as gas ovens.

Interesting Facts Concerning Refractories in the Iron and Steel Industry—C. E. NESBITT and M. L. BELL. Refractories are an important factor in the successful operations of the iron and steel industries. Good results will obtain if the producer of brick cooperates with the consumer, for the latter should know what the product must stand and the manufacturer must know the limitations of his product.

The range of temperature in the iron furnace varies from 260 deg. C. at the top to 1600 deg. C. at the tuyères. The chemical and physical properties should be known. Test conditions must be more severe than operating demands. Questions are raised by the tests given through the American Society of Testing Materials such as why the life of the same type of brick varies from 2 to 7 years or why converter bottoms last from two to six heats, and some of the individual bricks stand intact in these bottoms, while others are destroyed.

Simple tests should be evolved for use of the consumer so that quantity runs could be made. It has been evidenced, with a variation in temperature from 30 to 1350 deg. C. that the crushing strength is reduced 60 per cent, and that loss in open-hearth roofs have been 20 per cent with 261 heats due to fire cracks. The variation in chemical composition occurs when fumes penetrate the pores in open-hearth work. The

method of manufacture has a pronounced effect on the qualities of clay brick.

Superior Refractories—R. C. PURDY. The vital importance of the electric furnace calls for adequate refractories. The electric industry needs them for high-tension insulators, spark plugs in aircraft, etc. New high-temperature alloys, new glasses, new by-products demand superior refractories. The manufacturer and consumer must co-operate in developing the particular refractory for the special requirement.

As an illustration of refractory failures, fire clay may be taken. It ranges from 100 per cent kaolinite to complex mixtures in composition. The fusion in the brick during manufacture should be carried only to the required point without distortion, and there the heat action should be arrested. This point is largely determined by physical evidence. Melting points are resolved into melting ranges when a mixture of minerals is involved. A 1600 deg. C. brick might be finished at 1000 deg. C.

The essential requirements in superior refractories are heavy loads at high temperatures, no chemical action, constant volume, resistance to abrasion and sudden temperature changes; and these are met by physical strength, high fusibility and low volume changes.

The classification as regards acid, basic or neutral brick is not important. The exceptions are small in number. The future superior refractory may come from fused alumina, carborundum and so-called rare earths providing the cost is not prohibitive. Little bonding material is to be used and then fusible substances or silicate of soda only.

Refractory Problems in the Gas Industry—W. H. FULWEILER and J. H. TAUSSIG. Coal gas retorts operate at 1000-1200 deg. C. in one type, 1400-1500 deg. C., and 1350-1500 deg. C. in another type. The temperature at the top of retorts is about 850 deg. C. The internal surfaces have variation in temperature due to filling with coal at 12-hr. intervals. Both silica and fire brick are used with an expansion of $\frac{3}{16}$ in. per ft. above 300 deg. C. and $\frac{1}{16}$ in. per ft. gradually to 1100 deg. C., respectively.

These expansions make the problem of construction a difficult one. Cast iron supports and double arches must be allowed for. The various parts are kept in line and slip joints are provided. A mixture of 96 per cent silica and 1½ to 2 per cent lime is used in one type cement, and 55 per cent silica and 45 per cent alumina in another bonding material.

Water gas is made in three steel brick-lined shells connected in series, brick checkerwork filling in the last two. The first or geneator shell operates at a temperature of 1700 deg. C. in the highest part, where fine coke particles form a clinker on the sides. Steam is admitted at the bottom. The chemical effect of the clinker is not important at the top, but it must be frequently pried away from the brickwork, causing abrasion. Dropping to the floor of the generator, it reaches a high temperature (1100 to 1700 deg. C.), and chemically attacks the floor and lower wall.

Fire brick is used in the second and third shells because silica will not stand the sudden temperature changes caused by dosing every 4 min. with cold oil.

Zircon and carborundum bricks stand up well for gas work, but the cost is thirty times that of other grades. The better cements used in construction, and consisting of brick binder with a small amount of fusible material, are hard for the mason to work, because of poor spreading qualities. These features of expense must be weighed against the final improvement to determine the advisability of their adoption.

Symposium on Annual Patent Renewal Fees with the Division of Pharmaceutical Chemistry and Section of Dye Industry

The division met on Friday morning with a number of the members of Pharmaceutical and Dye Divisions present and Dr. MINER vacated the chair for E. J. PRINDLE. The members were asked to confine their remarks strictly to the subject at hand, as time did not permit the discussion of the patent situation in general.

Dr. HESSE had previously proposed by letter that taxes be imposed on U. S. patents, beginning with the eighth year. Quotation of part of his letter is as follows:

"Our patent system is founded on the constitutional provision that 'Congress shall have power to promote the progress of science and the useful arts, by securing for limited times to authors and inventors, the exclusive rights to their writings and discoveries.' It seems to me only fair to assume, therefore, that Congress is not to grant these exclusive rights if by so doing 'progress of science and useful arts' is needlessly impeded or obstructed.

"An inventor who allows his patent to lie idle transgresses the spirit underlying the patent system. He is reserving to himself a field of endeavor which he has agreed to exploit and is not exploiting, and by his reservation he prevents the exploitation by others and thus retards progress.

"A possible remedy for this might be a low annual tax, say from $15 to $25, or some other sum not high enough to stand in the way of any inventions giving any reasonable promise of remuneration, yet high enough to make it appear unprofitable to retain reservations which inventors are either unwilling, unable or incompetent to develop.

"When a German inventor forfeits his German patent he thereby opens that field for development and exploitation by Germans in Germany, but because he does not also at the same time relinquish his corresponding rights in the United States, we are barred by our own laws and by our own acts from enjoying a liberty of action and a freedom of invention which the Germans enjoy. A dead German patent, therefore, still lives and rules in the United States.

"I am of the opinion that such a tax system as here proposed would effectively remove much of the grip which foreign and especially German patent inventors have on our domestic industry, and would also relieve us of the congestion due to patents of our own citizens which are not exploited or serve no useful purpose and to some extent, at any rate, of that class of domestic patentees designated, more or less unjustly perhaps, as patent sharks, trailers or pirates."

Mr. PRINDLE stated the following points in regard to Dr. HESSE'S proposal should be considered:

1. Is the principle of patent taxation a sound one?
2. Would taxes restrict pirates?
3. Would taxes restrict the poor inventor?
4. Would they liberate patents from corporation control?

5. Would a new field be opened up?
6. Would held patents be forfeited?
7. Should patents be free from taxation the first seven years, and if not for what period?
8. What size of fee should be charged and should it remain stationary or increase?

Dr. L. H. BAEKELAND. The subject has been debated before. The system of patent laws in the United States is theoretically the most liberal of all countries and has been held up as a model one. There is a difference between theory and practice, however, and it is really intricate and complicated, to the detriment of the inventor.

The purpose of taxation is to eliminate so-called paper patents, some of which are a hindrance. The tax in European countries is a pretext at revenue collection. Under their systems a good many patents lapse and hardship is worked on the poor and honest inventor. The large companies gladly pay these renewal fees and the lapsed patents are largely those owned by individuals, the very people who need encouragement. Paper patents are eliminated, it is true, but the beginner is penalized.

The recent hearings in Washington on the patent situation are full of minor details, detracting from the fundamental changes really involved in the proposed House bills. They should forget these unimportant features and stick to main issues.

Dr. C. E. K. MEES, Eastman Kodak Co., presenting a paper written by Mr. STINCHFIELD, the company's patent attorney. If we examine fundamentals we will see that the principal object of the patent grant is to promote public interest in invention. The Government gives the inventor a limited monopoly in exchange for the free public use of this discovery later. The fees charged are only to cover the expenses of the Patent Office, and taxes should not be added.

The proposed taxation would not be equitable because the Government cannot cancel a contract with the inventor where his discovery has been previously revealed. His secret cannot be recalled.

No good will be accomplished by elimination of paper patents, as they harm nobody. It is like shooting a corpse. The live patents would not be allowed to lapse. Incentive to invention would be smothered. The tax would not be strong enough to help the situation. The forfeiting of unworked patents in Europe also acts unfairly, where they are immediately grabbed, and in cases of old patents becoming suddenly valuable the originator reaps no reward for his ideas.

The public secures something for nothing. Taxes are an especially heavy burden on the poor inventor and small business concern. If more fees must be charged, let it be done with the view of getting an adequate Patent Office organization in this country.

Dr. L. V. REDMAN. A system of fees is not satisfactory, if we assume our present patent principles are sound, i.e., that the monopoly given will stimulate invention and discovery. The renewal fee proposed would be justified if it eliminated the existing evils, but it would not do so. What applies in foreign countries does not apply here, due to differences in conditions. As a measure of reciprocity it would not work.

We cannot expect to correct abuses by taxing legitimate corporations for practicing their patents. Is the method of taking out and holding patents an abuse? A patent is fundamentally intended to be a monopoly. These contingent patents are not an abuse, because they are taken out to provide protection against parallel ideas intended to destroy the monopoly enjoyed by the basic patent. Their existence saves endless litigation.

The accusation that corporations take out contingent patents and withhold using the improvement is an assertion and not a proved fact. They must manufacture the best possible product or competition would spring up. If the good ideas were suppressed, the company would decay.

The patent pirate ties up new industries by taking out accessory patents to complicate the original claims without any intent to manufacture on his own account. He should be eliminated. Accessory patents should be allowed to the original inventor. There should be not taxes for revenue only, i.e., on working patents.

The chairman asked Mr. REDMAN if he thought such discrimination could be made and he replied that it could be by providing that no tax be placed on basic patents. The chairman called attention to the impossibility of reading the inventor's mind or intentions. Mr. REDMAN replied it was not hard to point out the pirate practically, but as to legal possibilities he could not say.

Mr. J. M. WEISS stated that true commercial patents would not be harmed by the small fees proposed and asked if Dr. BAEKELAND might not be mistaken in his statement that the majority of lapsed patents in European countries were those of poor inventors. He further stated that the taxes would clear the field of old patents which unfairly restrict development, because at the time they were taken out the inventor was not considering the field now affected.

Dr. BAEKELAND replied that he had personal acquaintance with a great many poor inventors both here and in Europe to whom the so-called small fee was an important item, often causing the loss of patents.

Mr. E. J. PRINDLE temporarily relinquished the chair to speak in substance as follows:

"Does the tax promote or deter the purpose for which the patent laws were enacted? Its purpose was to benefit the public by inducing inventors to reveal their secret by giving them a monopoly for a limited time and then it belonged to the public, adding to the treasury of public knowledge.

"Ours was the first practical patent system and ability to invent was rapidly developed in the people. The great wealth of this country is based largely on this fact. This inventive ability is not an inherent trait in our people, the majority of whom are descended from European stock, but is a result of our patent system. We should therefore be careful to do nothing to impair this situation.

"I wish to state that I am quite as much opposed to Germany's peaceful penetration, and quite as desirous of seeing her prevented from using unfair methods as Dr. HESSE can be. We should, however, consider any such proposal in the light of all its reactions and its effectiveness to accomplish that purpose.

"Any amendment to our patent law should conform to its fundamental purpose, which is to secure the production of inventions. The assumption and the fact are that inventions would ordinarily not be produced, if it were not for the inducements of the monopoly provided by the patent system.

"The path which the inventor must travel before

he can reap any return is already so difficult that many doubt that it is worth while to make inventions.

"The patent committee of the National Research Council has taken the position that the incentive of the inventor should be increased rather than diminished, and its report to that effect has been approved by this society, and by many scientific societies, and by several of the large trade organizations.

"The Supreme Court of the United States has decided that the patent law does not require the inventor to work his invention.

"The effect of the annual renewal would be to impose a burden which many individuals and corporations would hesitate to face. Many of the most important inventions have been made by comparative'y poor inventors on their own financial resources. and if, after having gotten their patents, they would still have to pay a series of annual taxes totaling a possible $550, and which in no way aided the exp'oitation of the invention, many of them would undoubted'y not attempt to make these inventions. The possibility of overlooking to pay the renewal fees, and thus losing all the time and money put into the invention and patent and all hope of future return, would act as a deterrent not only to the inventor but to any purchaser as well.

"Annual renewal fees would work a discrimination in favor of the rich man and the corporation against the average inventor.

"Furthermore, I do not believe that the imposition of annual taxes upon our patents would materially alter the German advantage under our patents. If a German-owned American patent were valuable in suppressing competition here, the Germans would unhesitatingly pay the renewal fees, even if they were much larger than the proposed taxes. If, on the other hand, the patent were so unimportant that the Germans would permit it to lapse for failure to pay the renewal fee, it would be of no advantage to us to be free to use it, for we should not want to use it.

"To be worth while a remedy must be one which will not only effectively check the Germans, but one which will not at the same time injure us—and more than them. The proposed remedy is not such a one.

Mr. HOLMES of the U. S. Patent Office was called upon and agreed with Mr. PRINDLE'S remarks.

Dr. T. HART ANDERSON telegraphed that he did not advocate a change, but was in favor of taxing foreign patentees as a matter of reciprocity. The taxes would probably be paid by them, however, on important patents.

Dr. J. M. FRANCIS wrote he was at a loss as to how to consider Dr. Hesse's letter. A tremendous stake is involved and our laws are good. A change might involve a terrible loss. The principles are good, but the remedy of taxation is poor, being a serious handicap to the young inventor.

Prof. ELIHU THOMPSON wrote he was opposed to the idea of fees, because the system of the Patent Office would be complicated by their collection. When an inventor is ahead of his time he should receive his reward when the development of the field calls for the use of his patent. The duration of time required for development of a basic idea after its first inception is sometimes very long, as in the case of large apparatus, and the reward should not be lost to the inventor.

Dr. W. R. WHITNEY of the General Electric Co. wrote that he would attempt to care specially for the question of the unfair standing of foreign inventors rather than reduce the favors extended to the American inventors. He declared that everything should be done to encourage young men to train themselves to be inventors.

Dr. A. D. LITTLE wrote that the fees in Europe were an unmitigated nuisance and the system should not be adopted.

E. A. HILL of the U. S. Patent Office wrote that the officials in the Patent Office organization agreed the burden of proof rests on those who want a change in the laws. Why experiment with the unknown? He is opposed to the tax, but recommends support of patent bills now before Congress.

Dr. HARLAN S. MINER proposed a resolution recommending to Congress that House bills Nos. 5011, 7010 and 5012 of the 66th Congress, first session, relating to patents and originally introduced through the patent committee of the National Research Council, be passed by that body. The resolution was unanimously carried. It was then suggested that each member of the A. C. S. write personal letetrs to his own Representative and Senators and also to John I. Nolan asking that the bills in question be favorably voted upon.

Continuation of Papers

Tensile Strength of Glue—G. HOPP. Viscosity and jelly strength have been used in testing glue, but tensile strength and stretch when applied are what is really required. The method of gluing boards and then pulling has not been satisfactory, since results obtained by this method were not uniform.

The new tests made consisted in molding the glue in strips, placing on a tin or aluminum screen to dry, and machining down to dimension required with a tolerance of about 0.001 in. Samples were then pulled in a 500-kg. machine with the jaws carefully aligned. Some of the results were as follows:

Glue	Stretch, Per Cent	Tensile Strength Lb.
No. 1	4½	13,240
No. 2	2	8,520
No. 3	2	7,600
No. 4	3½	11,570

These results are the average of a number of samples in each particular instance and the variation from the average was 1 to 3 per cent. The samples were kept under standard condition of temperature and humidity (75 deg. F. and 65 per cent humidity) until pulled, at room temperature. Complete test requires a maximum of five days.

Carbon Black—Its Properties and Uses—G. ST. J. PERROTT. An investigation of the carbon black industry has been undertaken by the Bureau of Mines as a result of economic issues brought up during the war. In the present process of manufacture carbon black is made by burning natural gas with an insufficient supply of air for complete combustion, collecting the liberated carbon on a metal surface. This process produces from ½ to 2 lb. per 1000 cu.ft. of gas or 1.5 to 6.5 per cent of the total carbon in the gas.

The process at first sight seems wasteful, but examination shows it is at any rate the only one in practical operation that produces carbon black suitable for the ink trade and rubber industry consumers, whose combined use is over 30,000,000 lb. annually. The whole situation appears to necessitate thorough investigation before any opinion can be given as to the wastefulness of the present process.

Accordingly the industry has been studied as to methods of manufacture and properties and uses of the finished product. Plants in Louisiana, Oklahoma and West Virginia have been investigated by Bureau engineers. Other processes of making carbon black have been investigated. The uses of carbon black have been studied with the idea of determining the properties of the product which users of carbon black demand and with an attempt at designating in which of these uses carbon black is essential and in which a substitute material might be employed. Microscopic and chemical analysis of a number of blacks has been made and test methods studied with a view to finding the reason for the very different behavior exhibited by different blacks, particularly as applied to the ink trade.

Adherent Rust as an Accelerator in the Corrosion of Iron and Steel—W. D. RICHARDSON. The experiments on which this paper is based lasted over a period of 1000 days and results were tabulated. If we look on corrosion as an electrolytic phenomenon, we then must consider iron as the anodes and the cathodes to be embraced in both the other substances in the metal, such as carbon and copper, and also outside substances lying on the surface of the metal. These latter take the form of oxygen, CO_2, oil, rust, etc.

Conclusion is that the dominant substance in the corrosion is oxygen. Hydrogen ions also play a part. Depolarizers consist of the rust and mill scale, the latter disappearing and leaving the rust to do the work. Clean iron surface is very sensitive to corrosion and the substance on its surface determines the speed with which it starts. Highly polished surfaces, being a coating of the pure metal smoothly spread over the pores and free from presence of internal impurities to act as cathodes, start to corrode very slowly. When clean without polish ferrite and carbon are present to start immediate electrolytic action.

Mill scale or rust over the surface stops the course of the corrosion. Under the rust is usually found a black film (Fe_3O_4), which assists in retarding the action. Oil or other substance acts in the same way.

Cast-iron plates 6 in. square and $\frac{1}{8}$ in. thick, and steel plates $\frac{1}{16}$ in. thick were used in the tests. These were placed in distilled water at rest, in distilled water with air agitation, in 10 per cent brine solution at rest and a 10 per cent brine solution with air agitation. In some cases the plates were removed and dried at intervals.

The losses by rust in brine were less than in distilled water because a smooth coating was soon formed which stopped further action, while in distilled water the rust was porous and action continued. Cast metals corrode less rapidly than steel metals due to nature of rust formed.

In no instance does the chemical composition of the metal influence the starting of corrosion, which really depends on some external substance, undoubtedly oxygen. The rate of corrosion after the start is made depends entirely on physical structure of rust formed.

Some Properties of Commercial Silicate of Soda—J. G. VAIL. Ordinary window glass is made from sand, soda and lime, melted together in a furnace. If we leave out the lime and increase the proportion of soda, the furnace yields a product, silicate of soda, which looks exactly like glass. This may be dissolved in water by the aid of special apparatus. The solution is the syrupy liquid familiar to almost everyone as water-glass. It has long been used for preserving eggs. More lately it has been found to possess many of the properties of glue. It is a strong adhesive. It sets rapidly. It cannot mold or spoil, and it is very much cheaper than glue.

As wood from our forests becomes more and more scarce, paper boxes, instead of wooden ones, are being used for shipping containers, but paper is neither thick enough nor strong enough to build boxes for shipping canned goods, shoes, soap, or the thousand and one things that are carried every day by the railroads. So the sheets of paper have to be pasted together, three, four and sometimes five-ply, to make a strong, tough product. For this the mineral adhesive, silicate of soda, is universally employed. It sticks so quickly that the rolls of paper can pass through the pasting machine at 150 ft. per min., and the combined board can be cut into sheets and fashioned into boxes without waiting for the adhesive to dry. After filling, the boxes are sealed with silicate of soda.

The box industry is growing, but there are a great many other industrial uses for a material to stick things together. Silicate of soda, the mineral adhesive, is the cheapest and the best for many of these purposes. It was hardly known for adhesive purposes 10 years ago, and scientific study of its properties and how to make and use it are constantly showing more ways to apply it. Animal and vegetable products which can be used for food are thus conserved for their rightful use. This is genuine economy.

The Leaching of Zinc Chloride From Treated Wood—ERNEST BATEMAN. This paper covered a large number of tests made on various woods by treating with 1 per cent, 3 per cent and 5 per cent solutions of zinc chloride, allowing to dry 28 days and testing. Results show the Cl radical comes out, leaving an excess of zinc. Basic zinc salts do not prevent decay, the Cl radical must be present to form $ZnCl_2$, or the wood is not protected from decay. The $ZnCl_2$ treated tie can be used in climates having not over 40 in. of rainfall per annum.

In addition to those outlined above the remainder of the 27 papers were read. These papers were of equal merit in the work covered. Each author showed long preparation and careful thought on his particular assignment. With such continued application of the individual member and a co-ordination of these efforts by the able leaders, one may well hesitate to predict the high state at which the industry will arrive during the coming decade.

Excursions

On Thursday afternoon seventeen of the representative plants of Philadelphia opened their doors to the convention. The bleach department of the Dill & Collins paper mills is described elsewhere in this issue. An account of the trip through the Atlantic Refinery, Barrett's, Electric Storage Battery, Foerderer, Warner and Welsbach plants will be given in the next issue.

For those wishing to avail themselves of the historical features offered in the Philadelphia vicinity, excursions were arranged to visit the old Colonial Capitol buildings containing the Liberty Bell and many objects of interest. Valley Forge, the winter camp of Washington's army in its final struggle before victory over Cornwallis, was visited by those who had seen the national shrines located in the city.

Program of Exposition Week

Fifth National Exposition of Chemical Industries—American Electrochemical Society—American Institute of Mining & Metallurgical Engineers — Technical Association of the Pulp & Paper Industry—American Ceramic Society—American Steel Treaters' Society

Fifth National Exposition of Chemical Industries

Coliseum and First Regt. Armory

Monday, Sept. 22

12 M.

Opening of Exposition.

2 P.M.

Meeting American Institute Mining & Metallurgical Engineers at Congress Hotel.

8 P.M.

Opening addresses at Chemical Exposition Auditorium.

GOV. FRANK O. LOWDEN of Illinois will made the address of welcome.

CHARLES H. HERTY, chairman of advisory committee, will respond.

JOHN W. O'LEARY, president Metal Trades Association of Chicago, "The Relation of the Chemist to the Manufacturer."

HERBERT H. DOW, "How Long Does It Take to Develop a Laboratory Process Into a Dividend?"

9 P.M.

Motion pictures in Chemical Exposition Auditorium.

Tuesday, Sept. 23

8 A.M.

Departure of members of the American Institute Mining & Metallurgical Engineers and American Electrochemical Society making excursion to steel mills at Gary, Ind.

2 P.M.

Symposium on "America's Case in Chemistry," at Chemical Exposition Auditorium, with ELLWOOD HENDRICK, president Chemists' Club and consulting editor CHEM & MET. ENG., as chairman.

"Dyestuffs," by J. MERRITT MATTHEWS, editor *Color Trade Journal.*

"Chemical Porcelain," by HERMAN S. COORS, of Herold China & Pottery Co.

"Laboratory Supplies; Lamp-Blown Glassware and General Apparatus," by C. G. FISCHER, of Scientific Materials Co.

"Glassware," E. C. SULLIVAN, of the Corning Glass Works.

"Laboratory Supplies; Instruments of Precision," by J. M. ROBERTS, secretary Apparatus Makers' Association of U. S.

"Optical Glass," by HARVEY N. OTT, of Spencer Lens Co.

8 P.M.

Motion pictures in Chemical Exposition Auditorium: "History and Utilization of Coal."

Joint Technical Meeting of American Institute of Mining & Metallurgical Engineers and American Electrochemical Society, on subject of "Iron and Steel," at Congress Hotel.

Wednesday, Sept. 24

10 A.M.

Meeting at Chemical Exposition of American Electrochemical Society for reading and discussion of papers.

Registration and meeting at Chemical Exposition of Technical Association of Pulp & Paper Industry in Officers Room, First Regiment Armory.

Address of welcome.

Opening address by president.

Report of executive committee.

Report of secretary-treasurer.

Reports by standing committees.

Meeting at Chemical Exposition of American Ceramic Society.

2 P.M.

Joint technical session American Electrochemical Society with American Institute Mining & Metallurgical Engineers at Chemical Exposition Auditorium.

2:30 P.M.

Meeting at Chemical Exposition of American Ceramic Society resumed.

3:30 P.M.

Meeting at Chemical Exposition of Technical Association of Pulp & Paper Industry resumed.

6:30 P.M.

Dinner of Technical Association of Pulp & Paper Industry at Union League Club.

8 P. M.

Motion pictures in Chemical Exposition Auditorium.

Thursday, Sept. 25

9:30 A.M.

Meeting at Chemical Exposition of Technical Association of Pulp & Paper Industry; general business meeting.

10 A.M.

Meeting of American Electrochemical Society jointly with American Institute of Mining & Metallurgical Engineers. Symposium on "Pyrometry" at Congress Hotel.

12 M.

Technical Association Pulp & Paper Industry adjournment for luncheon at, and as guests of, Sears, Roebuck & Co., to be followed by visit to the paper mill plant.

2 P.M.

Meeting at Chemical Exposition Auditorium.

"The Organization and Plans of the National Re-

search Council With Special Reference to the Industries," H. E. HOWE, National Research Council.

"Fields for Industrial Development, Canadian National Railways," PRICE GREEN, Industrial Commissioner, Canadian National Railways.

"Filtration," HENRY B. FABER, Industrial Filtration Corp.

"Destructive Distillation Bituminous Material with Reduced Vapor Tension and Complete Temperature Control," THOMAS W. PRITCHARD, vice-president Fuel Products Corp.

4 P.M.

Committee meetings Technical Association Pulp & Paper Industry at Chemical Exposition.

8 P.M.

Motion pictures at Chemical Exposition.

8 P.M.

American Electrochemical Society smoker at Congress Hotel.

8:30 P.M.

Technical Association Pulp & Paper Industry smoker.

Friday, Sept. 26

Technical Association Pulp & Paper Industry will visit Forest Products Laboratory at Madison, Wis.

9:30 A.M.

Meeting of American Electrochemical Society at Chemical Exposition Auditorium. Subject: Symposium on "Catalysis."

2 P.M.

Meeting of American Electrochemical Society resumed.

8 P.M.

Motion pictures. JAM HANDY, vice-president Bray Studios, address, "Art Exposes the Invisible in Chemistry," during the showing of special films.

"Natural Resources on C. N. Ry." PRICE GREEN, Industrial Commissioner of Canadian National Railways, address during showing stereopticon and motion pictures.

8 P.M.

Award of Willard Gibbs Medal to Prof. W. A. NOYES, University of Illinois, by Chicago Section of American Chemical Society.

Saturday, Sept. 27

9:30 A.M.

Meeting at Chemical Exposition headquarters of Technical Association of Pulp & Paper Industry for adjourned business session in auditorium.

AFTERNOON

Technical Association Pulp & Paper Industry official visits of inspection to exhibits at Chemical Exposition.

2 P.M.

Meeting at Chemical Exposition Auditorium. Symposium on Safety in Plant and Mine under chairmanship of M. F. LEOPOLD, safety engineer, U. S. Bureau of Mines.

8 P.M.

Motion pictures, depicting safety work in the plant and mine, by courtesy of U. S. Bureau of Mines.

American Electrochemical Society

Monday, Sept. 22

6 P.M.

Registration begins at headquarters, Congress Hotel. Society headquarters at Exposition in booths 235-236 on balcony of Coliseum.

Tuesday, Sept. 23

All-day excursion by boat with the American Institute of Mining & Metallurgical Engineers to Gary, Indiana, and trip through the United States Steel Co. plant. Details about tickets at the registration desk.

10 A.M.

Meeting of Directors.

12 M.

Luncheon at Steel plant.

1:30 P.M.

Inspection of United States Steel Co's plant.

Joint technical session with the A. I. M. & M. E. General subject: "Iron and Steel."

8 P.M.

Joint technical session with the A. I. M. & M. E. at the Congress Hotel (continued).

Wednesday, Sept. 24

10 A.M.

Reading and discussion of papers at Chemical Exposition Auditorium.

"Manganin," M. A. HUNTER and J. W. BACON.

"The Activation of Carbon," N. K. CHANEY.

"Depreciation in Small Dry Cells With Age," A. J. HELFRECHT.

"The Effect of Amalgamation Upon the Single Potential of Aluminum," LOUIS KAHLENBERG and JOHN A. MONTGOMERY.

"The Effect of Amalgamation Upon the Single Potential of the Binary Alloys of Al With Cu, Zn and Ni," LOUIS KAHLENBERG and JOHN A. MONTGOMERY.

2 P.M.

Joint technical session with the A. I. M. & M. E. at Chemical Exposition Auditorium. General subject: "Ferrous and Non-Ferrous Metallurgy."

"Radiant Resistor Furnace," F. A. J. FITZGERALD.

"Electric Heat in the Typewriter Industry," A. M. CLARK.

"Electric Furnace for Experimental Work," F. A. J. FITZGERALD.

"A Square Deal for the Electric Furnace," H. G. WEIDENTHAL.

(See also papers for this session on the program of the A. I. M. & M. E.)

EVENING

Inspection of the electric furnace exhibits at the Exposition.

8 P.M.

Motion pictures in Exposition auditorium.

Thursday, Sept. 25

10 A.M.

Joint technical session with A. I. M. & M. E. Symposium on Pyrometry at Congress Hotel.

2:30 P.M.

Continuation of joint session.

8 P.M.

Complimentary smoker at Congress Hotel, tickets of admission to be obtained from the registrar.

Friday, Sept. 26

Symposium on Catalysis at the Chemical Exposition Auditorium.

"Some Problems in Contact Catalysis," W. D. BANCROFT.

"Further Problems in Contact Catalysis," H. S. TAYLOR.

"The Thermal Problem in Organic Contact Catalysis," W. J. HUFF.

"Thermal Problem in the Contact Process of Sulphuric Acid Manufacture," F. C. ZEISBERG.

"Modern Theories of Matter and the Problem of Catalysis," E. K. RIDEAL.

2:30 P.M.

Meeting at Exposition Auditorium.

"Demonstration of Manufacture of Fluorine," F. C. MATHER and BURR HUMISTON.

"Factors Governing the Structure of Electrodeposited Metals," WILLIAM BLUM.

"Lead Plating From Fluoborate Solutions," WILLIAM BLUM, F. J. LISCOMB, ZALIA JENKS and W. E. BAILY.

"Commercial Possibilities in Electrochemical Production of Organic Compounds," C. J. THATCHER.

American Institute of Mining and Metallurgical Engineers

Monday, Sept. 22

MORNING

Registration begins at headquarters, Congress Hotel.

11 A.M.

Technical Sessions:

1. Session on Non-Ferrous Metallurgy and Metallography.

The papers will be read here by title only to afford opportunity for discussion when presented at the Philadelphia meeting of the Institute of Metals Division.

2. Session on Coal and Gas.

2 P.M.

Technical Sessions:

1. Session on Coal and Gas.
2. Session on Geology.
3. Session on Milling.
4. Session on Industrial Organization.

EVENING

Smoker.

Tuesday, Sept. 23

MORNING AND AFTERNOON

Excursion by boat with the American Electrochemical Society to Gary, Ind., and trip through the United States Steel Co. plant. During the afternoon upon the return trip, on the boat, technical session on Iron and Steel, jointly with American Electrochemical Society.

"Blast-Furnace Refractories," RAYMOND M. HOWE.

"Effervescing Steel," HENRY D. HIBBARD.

"Aircraft Steels," ALBERT SAUVEUR.

"Determining Gases in Steel and the Deoxidation of Steel," J. R. CAIN.

"Effect of Time and Low Temperature on Physical Properties of Medium-Carbon Steel," G. A. REINHARDT and H. L. CUTLER.

"Erosion Tests of Rifle Barrels," A. E. BELLIS.

"Metallography of Rifle-Barrel Steel," G. F. BUTTERWORTH.

8 P.M.

Session on Iron and Steel, jointly with American Electrochemical Society (continued):

"Industries of the Chicago District," T. W. ROBINSON, lantern slides, etc.

"Manufacture of Steel Rails," ROBERT W. HUNT.

"240-inch Plate Mill," C. L. HUSTON.

8 P.M.

Session on Oil:

"Irvine Oil District, Kentucky," STUART ST. CLAIR.

"Petroliferous Provinces," E. G. WOODRUFF.

"Investigations Concerning Oil-Water Emulsion," A. W. MCCOY, H. R. SHIDEL and E. A. TRAGER.

"Essential Factors in the Valuation of Oil Properties," CARL H. BEAL.

"Application of Law of Equal Expectations to Oil Production in California," CARL H. BEAL and E. D. NOLAN.

"Value of American Oil Shales," CHARLES BASKERVILLE.

Wednesday, Sept. 24

10 A.M.

Technical Sessions:

1. Session on Iron and Steel:

"Cooling Properties of Technical Quenching Liquids," N. B. PILLING and T. D. LYNCH.

"Differential Crystallization in Cast-Steel Runner." FRANCIS B. FOLEY.

"Manufacture and Properties of Light Wall Structural Tubing," H. J. FRENCH.

"Oxygen in Cast Iron and Its Application," WILFORD L. STORK.

"Graphitization of White Cast Iron Upon Annealing," PAUL D. MERICA and L. J. GUREVICH.

"Experimental Data Obtained on Charpy Impact Machine," F. C. LANGENBERG.

"Heat Treatment of Cast Steel," JOHN H. HALL, ARVID E. NISSON and KNOX TAYLOR.

2. Mining and Local Resources:

"Winconsin Zinc District," W. F. BOERICKE and T. H. GARNET.

"Mineral Resources of the La Salle District," J. A. EDE.

"New Angles to the Apex Law," JOHN A. SHELTON.

"Mining Methods of Alaska Gastineau Mining Co.," G. T. JACKSON.

"Tunnel Driving at Copper Mountain, B. C." (Columbia Section Paper), OSCAR LACHMUND.

"Geology and Mining Methods at Pilares Mine," ALFRED WANTKE, W. ROGERS WADE.

"Wedging Diamond-drill Holes," O. HALL and V. P. ROW.

3. Session on Sulphur in Coal:

"Geographic Distribution of Sulphur in the West Virginia Coal Beds," I. C. WHITE.

"Occurence and Origin of Finely Desseminated Sulphur Compounds in Coal," RHEINHARDT THIESSEN.

"Mechanical Separation of Sulphur Minerals From Coal," J. R. CAMPBELL.

"Sulphur in Coal—Geological Aspects," GEORGE H. ASHLEY.

"Forms in Which Sulphur Occurs in Coal," A. R. POWELL.

"Effect of Sulphur in Coal Used in Ceramic Industries," C. W. PARMELEE.

2 P.M.

Technical Sessions:

1. Session on Non-Ferrous Metallurgy, jointly with American Electrochemical Society at Chemical Exposition Auditorium :

"Electric-Resistance Furnace of Large Capacity for Zinc Ores," CHARLES H. FULTON.

"Water and Chlorides in Cement Copper," EDWARD KELLER.

"Chemical and Electrochemical Problems Involved in the New Cornelia Copper Co.'s Leaching Process." HENRY S. MACKAY.

"Electrolytic Zinc," C. A. HANSEN.

"Treating Antimony Ores," GEORGE P. HULST.

2. Session on Sulphur in Coal:

"Removal of Sulphur From Illuminating Gas," W. W. ODELL and W. A. DUNKLEY.

"Low Sulphur in Coal," H. M. and T. M. CHANCE.

"Low-Sulphur Coals of Kentucky," WILLARD R. JILLSON.

"Low-Sulphur Coal in Illinois," GILBERT H. CADY.

"Sulphur in the Coking Process," S. W. PARR.

"Commercial Recovery of Pyrite from Coal," S. H. DAVIS.

"Sulphur in Producer Gas," FREDERICK CRABTREE and A. R. POWELL.

3. Session on Pyrometry With Special Reference to Iron and Steel Metallurgy:

Report of the Pyrometer Committee of National Research Council, George K. Burgess.

"Pyrometry in Blast-Furnace Work," P. H. ROYSTER and T. L. JOSEPH.

"Pyrometry and Steel Manufacture," A. H. MILLER.

"Electric Open Hearth and Bessemer Steel Temperatures," F. E. BASH.

"Some Thermal Relations in the Treatment of Steel," CHARLES F. BRUSH.

"Pyrometry in the Tool Manufacturing Industry," J. V. EMMONS.

"Forging Temperatures and Rate of Heating and Cooling of Large Ingots," F. E. BASH.

Evening

Banquet at Congress Hotel.

Thursday, Sept. 25

10 A.M.

Optional excursion to De Pue, Ill., by train for inspection of zinc smelters, cement works and coal mines.

Trip to Starved Rock and points of historical interest.

10 A.M. and 2 P.M.

Technical meeting, subject: Symposium on Pyrometry, jointly with American Electrochemical Society:

"Temperature," J. S. AMES.

"Standard Scale of Temperature," C. W. WAIDNER. E. F. MUELLER and PAUL D. FOOTE.

"Metals for Pyrometer Standardization," C. W. WAIDNER and GEORGE K. BURGESS.

"Fundamentals of Pyrometry," C. E. MENDENHALL.

"Thermo-electric Pyrometry," PAUL D. FOOTE, T. R. HARRISON and C. O. FAIRCHILD.

"Potentiometers for Thermo-element Work," WALTER P. WHITE.

"Self-Checking Galvanometer Pyrometer," H. F. PORTER.

"Some Factors Affecting the Use of Base-Metal Thermocouples, O. L. KOWALKE.

"Curves and Tables to Represent the Relation Between Thermal E.M.F. and Temperature," L. H. ADAMS.

"Reference Standard for Base-Metal Thermocouples," N. E. BONN.

"Alloys Suitable for Thermocouples and Base-Metal Thermo-electric Practice," J. M. LOHR.

"Recent Improvements in Pyrometry," R. P. BROWN.

"Automatic Correction for Temperature of Cold Junctions," F. WUNSCH.

"A Hot Wire Anemometer With Thermocouple," T. S. TAYLOR.

"Porcelain for Pyrometric Purposes," F. H. RIDDLE.

"Pyrometer Porcelain and Refractories," R. W. NEWCOMB.

"Porcelain Pyrometer Protecting Tubes," F. A. HARVEY.

"Porcelain Tubes for Thermocouples," R. B. LINCOLN.

"Melting Point for Refractory Materials," LEO I. DANA.

"High Temperature Scale and Its Application in the Measurement of True Brightness and Color Temperature," EDWARD P. HYDE.

"Theory and Accuracy in Optical Pyrometry," W. E. FORSYTHE.

"Optical and Radiation Pyrometry," PAUL D. FOOTE and C. O. FAIRCHILD.

"Industrial Application of the Disappearing-Filament Type of Optical Pyrometers," F. E. BASH.

"Use of the Optical Pyrometer for Control of Optical-Glass Furnaces," C. N. FENNER.

"Emissive Powers and Temperatures of Non-Black Bodies," A. G. WORTHING.

"Recording Thermocouple Pyrometers," LEO BEHR.

"Recording Pyrometry," C. O. FAIRCHILD and PAUL D. FOOTE.

"A Remote Control Valve Operating Mechanism for Hand or Automatic Control," R. W. NEWCOMB and C. ENGLEHARD.

"High Temperature Control," C. O. FAIRCHILD and PAUL D. FOOTE.

"Resistance Thermometry," F. W. ROBINSON.

"Tin an Ideal Pyrometric Material," E. F. NORTHRUP.

"Resistance Thermometry for Industrial Use," CHARLES P. FREY.

"Temperature Measurement in Optical Glass Annealing Furnaces," E. D. WILLIAMSON and H. S. ROBERTS.

"Annealing of Glass," A. Q. TOOL and J. VALASEK.

"Pyrometry Applied to Bottle-Glass Manufacture," R. L. FRINK.

"Pyrometry in the Manufacture of Optical Glass," ALBERT J. WOLCOTT.

"Pyrometry as Applied to the Manufacture of Optical Glass," CARL W. KEUFFEL.

"Pyrometer Shortcomings in Glass-House Practice," W. M. CLARK and CHARLES D. SPENCER.

"Temperature in the Manufacture of Pottery," F. K. PENCE.

"Pyrometry in the Chemical Industry as Applied to Gas Mask Manufacture," K. MARSH.

"Application of Pyrometry to the Ceramic Industries," C. B. THWING.

"Pyrometry in Rotary Portland Cement Kilns," by LEO I. DANA and C. O. FAIRCHILD.

"Application of Pyrometers to Ceramic Industry," JOHN P. GOHEEN.

"Temperatures of Incandescent Lamp Filaments," BENJAMIN E. SHACKLEFORD.

"Temperature Measurements of Incandescent Gas Mantles," H. E. IVES.

"Application of Pyrometry to Problems of Lamp Desire and Performance," I. H. VAN HORN.

"Use of Modified Rosenhain Furnace for Thermal Analysis," H. SCOTT and J. R. FREEMAN.

"High Temperature Thermometers," R. M. WILHELM.

"Temperature of a Burning Cigar," T. S. SLIGH and C. S. KRAYBILL.

"Teaching Pyrometry in Our Technical Schools," GEORGE V. WENDELL.

"Teaching Pyrometry," C. E. MENDENHALL.

"Teaching Pyrometry," O. L. KOWALKE.

"Present Status of Radiation Constants," W. W. COBLENTZ.

"Pyrometer Protection Tubes," OTIS HUTCHINS.

Friday, Sept. 26

Continuation of adjourned Technical Sessions:

MORNING

Optional Trips.

1. North Chicago and Milwaukee.
2. East Chicago metallurgical plants and oil refineries at Whiting, Indiana.
3. Local Chicago plants.
4. Coal trip to Franklin and Macoupin counties.

Technical Association of the Pulp and Paper Industry

The following tentative program of meetings, excursions and entertainments of the Technical Association of the Pulp & Paper Industry, Chicago, has been prepared. More extensive details appear in the final program.

Sept. 24, 25, 26 and 27—All meetings are to be held in conjunction with the Fifth National Exposition of Chemical Industries in the officers' Board Room of the First Regiment Armory, Sixteenth St. and Michigan Boulevard, and at the Coliseum, Wabash Ave. and Fifteenth St., Chicago. Admission by T. A. P. P. I. badge. Members are requested to register at T. A. P. P. I. booth, No. 237, and at the entrance to the Armory, immediately on arrival any time during the week.

Wednesday, Sept. 24

10 A.M.

Opening meeting in First Regiment Armory.

Address of welcome.

Opening remarks by the president.

Report of the executive committee.

Report of the secretary-treasurer, followed by reports of standing committees:

Abstracts of Literature, ROSS CAMPBELL, chairman.

Bibliography, HENRY E. SURFACE, chairman.

Heat, Light and Power, EDWARD P. GLEASON, chairman.

Paper Testing, FREDERICK C. CLARK, chairman.

Soda Pulp, MARTIN L. GRIFFIN, chairman.

Standard Methods of Testing Materials Used in the Manufacture of Paper, WILLIAM H. GESELL, chairman.

Sulphate Pulp, OLAI BACHE-WIIG, chairman.

Sulphite Pulp, HERBERT G. SPEAR, chairman.

Vocational Education, GEORGE E. WILLIAMSON, chairman.

Among the special papers and reports to be presented and discussed is one entitled "The Principles and Practice Involved in Washing Unbleached Soda Pulp." This will form the report of the committee on Soda Pulp, MARTIN L. GRIFFIN, chairman.

The committee on Sulphate Pulp, O. BACHE-WIIG, chairman, will make a report on tests which have been made to determine the loss of soda in the evaporation of black liquor in sulphate mills. The report is not expected to be a lengthy one, but it will be characterized by great accuracy, the tests having been made by the same chemists in a number of different pulp mills. Methods of overcoming avoidable waste will be described in the report.

The committee on Paper Testing, FREDERICK C. CLARK, chairman, promises a revised report on methods of testing paper which should prove of great interest and value.

3:30 P.M.

Adjourned session in First Regiment Armory.

The committee on Sulphite Pulp will report on new methods of handling waste liquor from digesters and of cooling the SO_2 gas from burners.

An account of research work on the important problem of waste sulphite liquor utilization will be presented by Prof. RALPH H. MCKEE and GEORGE BARSKY, of Columbia University, in a paper entitled "Fuel From Waste Sulphite Liquor."

6:30 P.M.

Dinner at the Union League Club.

Thursday, Sept. 25

9:30 A.M.

Business meeting at Registration Booth in Coliseum.

1 P.M.

Adjournment for visit to paper mill plant of Sears, Roebuck & Co.; luncheon as guests of the firm.

2 P.M.

Inspection tour of the Sears, Roebuck & Co., plant.

4 P.M.

Committee meetings and special papers.

7 P.M.

Illustrated address by Dr. R. J. BLAIR, pathologist, Forest Products Laboratories of Canada, McGill University, Montreal, on "Prevention of Decay in the Timber of the Roofs of Pulp and Paper Mills," followed by smoker and entertainment.

Friday, Sept. 26

The day will be spent in a visit of inspection to the Forest Products Laboratory of the Forest Service, U. S. Department of Agriculture, Madison, Wis. Train arrangements provide for members taking a late train from Chicago on Thursday evening and arriving in Madison early Friday morning, or leaving late in the afternoon so as to reach Madison shortly after 9 o'clock in the evening. Hotel accommodations at Park Hotel. The departure from Madison will be made on Friday at 5:40 P. M., arriving in Chicago at 10:30 P.M. The first class fare from Chicago to Madison is $4.21, and sleeper berth $1.60. Notice of intention to take the trip should be sent promptly to Chairman Savery.

Saturday, Sept. 27

9:30 A.M.

Adjourned business sessions at the National Exposition of Chemical Industries.

American Ceramic Society

Program for "Ceramic Day" at the Fifth National Exposition of Chemical Industries, the Coliseum, Chicago, Sept. 24, 1919.

10 A.M.

"The American Ceramic Society, Past, Present and Future," Prof. CHARLES F. BINNS.

"Buy on Analysis," Dr. ALEXANDER SILVERMAN.

"Superior Refractories," ROSS C. PURDY.

"The Making of Pottery," FREDERICK H. RHEAD.

2:30 P.M.

"General Types of Optical Glass," ROBERT J. MONTGOMERY.

"Brick and Tile," DOUGLAS F. STEVENS.

"The Application of Scientific Methods to Ceramic Research," A. V. BLEININGER.

"The Manufacture of Optical Glass," Dr. J. C. HOSTETTER.

"Enameling Technology," R. R. DANIELSON.

Other addresses will be delivered at both morning and afternoon sessions.

8 P.M.

Motion pictures, including:

1. "Making Cut Glass."
2. "Glass Bulb and Tubing Manufacture for Mazda Lamps."
3. "Making Window Glass."

BANQUET

It is urged that all members and their friends attend the dinner at 6 P.M., New Southern Hotel, 1250 South Michigan Ave., very near the Coliseum. Tickets at $2 each can be secured at the Society's booth, No. 229, during the day, Sept. 24.

HEADQUARTERS

The headquarters of the American Ceramic Society throughout the Exposition week will be at Booth 229, at which representatives of the Society will be in constant attendance. It is urged that all members make their headquarters at the booth and everyone who is any way interested in the silicate industries will be most welcome. Any information which can be gotten for the assistance of any visitor will be obtained. At the booth there will be literature regarding the ceramic industry and the American Ceramic Society.

American Steel Treaters' Society

Tuesday, Sept. 23

9 A.M.

Registration Seventh Regiment Armory.

10 A.M.

Address of welcome: Hon. HARRY H. MERRICK, president Chicago Association of Commerce.

Address of welcome: Acting President T. E. BARKER.

Report of Acting Board of Directors by Acting Secretary A. G. HENRY.

Report of Finance Committee: Acting Chairman A. F. BOISSONEAU.

Paper: "Relation of Heat Treatment, Design and Selection of Steels for Metal Cutting Tools to Factory Production; C. P. BERG, president C. P. Berg & Co., consulting engineers.

Visit to Exhibits.

2 to 4:30 P.M.

Presiding officer, HORACE H. CLARK, chairman Chicago Chapter.

2 P.M.

Report of tellers of election. Adress of president-elect.

Papers: "Heat Treatment of Steels for Cutting Purposes."

8-10 P.M.

Presiding officer, G. WALTER ESAU, chairman Milwaukee Chapter. Papers: "Case Hardening in General."

Wednesday, Sept. 24

10-12 A.M.

Presiding officer, DAVID BELL, chairman Buffalo Chapter. Papers: "Heat Treatment of Miscellaneous Products."

2-4 P.M.

Presiding officer, B. F. WESTON, chairman Pittsburgh Chapter. Papers: "Heat Treatment of Steel for Intermittent Cutting Purposes."

8-10 P.M.

Presiding officer, GEORGE W. PRESSELL, chairman Philadelphia Chapter. Papers: "Results of Investigation Pertaining to Heat Treatment."

Thursday, Sept. 25

10-12 A.M.

Presiding officer, W. S. BIDDLE, chairman Cleveland Chapter. Papers: "Heat-Treating Equipment."

2-4:30 P.M.

Presiding officer, FRANK P. FAHY, chairman New York Chapter. Papers: "Solution of Modern Demands on Heat Treating."

6:30 P.M. Sharp

Informal banquet and entertainment, Cameo Room, Morrison Hotel. Tickets $3.

Friday, Sept. 26

10 A.M.

Exhibit at Seventh Regiment Armory. Plant visitation.

7-10 P.M.

Band concert. Third Regiment Military Band.

Saturday, Sept. 27

"Chicago Day."

Exhibition open 10 A.M.-10 P.M.

1:30 P.M. and 7 P.M.

Band Concert. Third Regiment Military Band.

The Papers

An extensive list of papers, covering the very latest developments in every field of the heat-treating art, has been prepared. The papers given below form but a small part of the completed program:

"Modern Pyrometry," A. W. ANDERSON, C. S. Gordon Co.

"Metallography of Steel," CYRIL J. ATKINSON, Laboratories, Milwaukee, Wis.

"Annealing Large Sections of Cast Nickel Steel," G. A. BREWSTER, American Steel Foundries, Chicago, Ill.

"Salts for Quenching," SHIPLEY N. BRAYSHAW, London, England.

"Relation of Heat Treatment, Design and Selection of Steels for Metal Cutting Tools to Factory Production," C. P. BERG, C. P. Berg & Co., Chicago, Ill.

"Results of Investigations Pertaining to Heat Treating," RAY T. BAYLESS, James H. Herron Co., Cleveland, Ohio.

"Pyrometry," R. P. BROWN, president Brown Instrument Co., Philadelphia, Pa.

"Cast Steel," ALVIN N. CONARROE, chemist and metallurgist, National Malleable Castings Co.

"Electric Heating of Steel," E. F. COLLINS, General Electric Co.

"Case Hardening in General," WILLIAM G. CONNER, George D. Whitcomb Manufacturing Co., Rochelle, Ill.

"Heat Treatment of Balls for Bearings," ARTHUR L. COLLINS, Atlas Ball Co., Philadelphia.

"Effects of Forging Temperatures on Heat Treatment of Steels," D. R. CORNELL, Standard Forgings Co., Indiana Harbor, Ind.

"Heat Treatment of Cast Steel," WILLIAM GEORGE DAUNCEY, Associate Editor, *Iron and Steel*, Montreal, Canada.

"Heat Treatment of Cast Steel in Tractor Construction," FRED GROTTS, Holt Manufacturing Co., Peoria, Ill.

Chicago Exhibitors

The following societies and publications will have booths, in which they will be glad to receive their friends:

AMERICAN CERAMIC SOCIETY.
AMERICAN CHEMICAL SOCIETY.
AMERICAN DYES INSTITUTE.
AMERICAN ELECTROCHEMICAL SOCIETY.
CANADIAN CHEMICAL JOURNAL.
CANADIAN MINING JOURNAL.
CANADIAN TEXTILE JOURNAL
CHEMICAL CATALOGUE CO, INC.
CHEMICAL & METALLURGICAL ENGINEERING.
CHEMICAL ENGINEER.
CHICAGO SECTION, AMERICAN CHEMICAL SOCIETY.
COLOR TRADE JOURNAL.
INDUSTRIAL & EDUCATIONAL PRESS.
IRON & STEEL OF CANADA.
JOURNAL OF COMMERCE.
JOURNAL OF INDUSTRIAL AND ENGINEERING CHEMISTRY.
MCGRAW-HILL CO.
MANUFACTURERS' RECORD.
OIL, PAINT & DRUG REPORTER.
PAPER.
PULP & PAPER MAGAZINE OF CANADA.
TECHNICAL ASSOCIATION OF THE PULP & PAPER INDUSTRY.
TEXTILE COLORIST.

The names of the representatives and brief itemization of products of the exhibitors are given as received up to the closing date of this issue. Over 330 firms are taking advantage of the excellent opportunity offered in the Chicago Exposition to extend their acquaintance in the Central States.

PAUL O. ABBE—Crushing, cutting, pulverizing, disintegrating, mixing and sifting machinery. Special features—motor-driven, self-contained unit jar and pebble mills, Gruendler hammer mills, Mead mills, etc. In charge of exhibit: Paul O. Abbe, Henry Sellman and John Buckley.

ABBE ENGINEERING CO.—Pebble mills, disintegrators, Max mills, bolting cloth, featuring motor-driven laboratory mills. In charge of exhibit: H. F. Kleinfeldt and W. S. Ransom.

THE ABBOTT LABORATORIES—Synthetic pharmaceuticals, such as barbital, chlorazene, chlorcosane, dichloramine-T, histidine, calcium, copper, mercury, sodium and zinc phenolsulphonates, etc. The features of the exhibit will be a working model of the manufacture of chlorazene from coal tar, and a physiologic testing demonstration of anesthetics and hypnotics. In charge of exhibit: W. F. Straub, E. H. Vollweiler, Carl Nielsen and Norman Hansen.

WILLIAM AINSWORTH & SONS.—Three analytical balances. In charge of exhibit: A. W. Ainsworth.

ALBANY FELT CO.—A complete line of all wool-woven filter cloths for the various methods of filtration. These cloths work most successfully in aniline dye plants and also in plants manufacturing the heavier chemicals. There will also be samples of paper mill felts used by manufacturers of newsprint, bonds, writings, tissues, boards and pulps. In charge of exhibit: Walter S. Rooney.

THE ALBERENE STONE CO.—Various laboratory equipment including a standard hood, consisting of a complete superstructure of Alberene stone and wireglass with sliding sash, work-tables, reagent shelves and a chemical sink with drainboard and pegboard for washing and drying glassware. A special photograph tank for X-ray purposes will be found of interest to physicians and others interested in X-ray work. In charge of exhibit: Warren K. Fields, F. A. Buss.

ALLEN ELECTROLYTIC CORP

AMERICAN BALLAST CO. (formerly the AMERICAN LIMESTONE CO.)—Various kinds of limestone in various conditions of preparation from a sample of rock down to ground material, which will be 200-mesh in fineness. In charge of exhibit: Scott A. Fones.

AMERICAN CHEMICAL & MANUFACTURING CO.—"Hippo" waterproofing products, including acid, water and shower proof textiles; waterproof concrete, concrete floor hardener; acid-proof, oil-proof, brine-proof coatings for steel; lacquers for food tins, etc.; insulating varnishes for transformer coils; wall primer to prevent leaching of calcium salts. In charge of exhibit: Charles D. Stillman, W. M. Van Ostrom and R. C. Dederick.

AMERICAN CYANAMID CO.—The principal features will be a series of models accompanied by brief descriptive matter showing the process of fixing nitrogen from the air in the form of cyanamide together with samples of all cyanamide products, with brief descriptions of their principal uses. In charge of exhibit: E. J. Pranke and J. P. Hubbell.

AMERICAN HARD RUBBER CO.—An electrically driven hard rubber centrifugal pump, pumping through a hard rubber pipe into hard rubber tanks. The only material which comes in contact with the liquid is hard rubber. Small reciprocating pumps and other articles will illustrate the various uses to which hard rubber can be put. In charge of exhibit: A. M. Ackerman and E. D. Madden.

AMERICAN KRON SCALE CO.—One of the standard portable scales of the type adopted by the American Railway Express Co. will be exhibited to demonstrate claims as to durability and strength. In charge of exhibit: Carl F. Larson and John M. Bjornson.

AMERICAN LA FRANCE FIRE ENGINE CO.

AMERICAN METAL PRODUCTS CO. "Ampco" metal, both castings and sheet, including valves, calorimeter bombs, runners, liners, etc. designed to resist the corrosive action of all commercial acids. In charge of exhibit: H. C. Brelie, Miss E. T. Smith, R. W. Alger and C. J. Zaiser.

AMERICAN METER CO.—A No. 302 calorimeter set, new type of cubic foot standard as described in technologic paper No. 114 of Bureau of Standards, a $\frac{1}{10}$-cu.ft. bottle, set of gages, specific gravity apparatus, service cleaner, and various types of test meters. In charge of exhibit: H. D. Harper and J. G. Barrett.

AMERICAN ROLLING MILL CO.

AMERICAN TRANSMARINE CO.

AMERICAN WATER SOFTENER CO.

ANACONDA COPPER MINING CO.—(See Raritan Copper Works).

H. REEVE ANGEL & CO.—Whatman filter papers, including two new products, viz: Strips for arsenic determinations and absorption blocks. Filter papers of American manufacture, including the Alpha No. 190, Lion, Griffin Gray and Climax brands. "Labruco" pure gum rubber tubing, filter mass, glass wool, etc. In charge of exhibit: Byron S. Proper.

ANILINE DYES & CHEMICALS, INC.

ARKELL SAFETY BAG CO.—Linings for shipping packages such as barrels, boxes, drums and bags. The linings will be shown inserted into the different packages ready for use. In charge of exhibit: P. J. Morales and John B. Judson, Jr.

ARMSTRONG CORK CO.—Insulating material for hot and cold surfaces; nonpareil corkboard insulation for refrigerated and constant temperature rooms, nonpareil cork covering for cold pipes and tanks, nonpareil insulating brick for furnaces and other high temperature equipment. The feature will be an electrically heated furnace so arranged as to give a tangible demonstration of the difference in the heat-conducting qualities of nonpareil brick and ordinary brick. In charge of exhibit: S. L. Barnes.

ARNOLD, HOFFMAN & CO., INC.—A joint exhibit with the MATHIESON ALKALI WORKS and the NITROGEN PRODUCTS CO. (*q.v.*). Finishing and sizing materials for textile and other trades and a line of pigment colors. In charge of exhibit: Adriaan Nagelvoort, Otto A. Fritz and H. D. Winship.

W. O. ARZINGER MACHINERY CO.—A complete working model of the Simplex flotation process on straight and selective flotation. In charge of exhibit: W. O. Arzinger.

ATLAS ELECTRIC DEVICES CO.

ATLAS POWDER CO.—Special bottles of chemical products, high explosives, dynamite, blasting supplies and blasting powder. In charge of exhibit: E. E. Rese, E. L. B. Baptiste and H. V. Clark.

THE AUSTIN CO.—Photographs and descriptive matter of some of the chemical plants designed, constructed and equipped by this company. Working models of Austin standard buildings, together with actual sections of the materials entering into their construction. In charge of exhibit: C. F. Chard.

BACHMEIER CO., INC.—An exhibit of aniline dyes. In charge of exhibit: J. H. Bachmeier, G. M. Lord and E. J Struck.

BAILEY METER CO.—Various types of Bailey fluid meters for measuring steam, water, gases and chemicals; V-notch Weir meter, 50,000 lb. per hour capacity, in operation; two fluid meters in operation, one with orifice in 4-in. water line, the other with orifice in 6-in. air line. In charge of exhibit: E. G. Bailey and W. E. East.

J. T. BAKER CHEMICAL CO.—A line of chemical reagents specifically known as "Baker's analyzed chemicals." In charge of exhibit: William P. Fitzgerald.

BAUSCH & LOMB OPTICAL CO.

THE BARRETT CO.—Joint exhibit with National Aniline & Chemical Corporation, General Chemical Co., Semet-Solvay Co., and the Solvay Process Co. The Barrett Co. will contribute a chart showing (by means of samples) the interrelation of about 200 coal-tar products. A newly developed coal-tar resin, paracoumarone (trade name Cumar); Naphthalene; benzols, toluols; phenols, cresols, cresylic acids, etc., will also be shown. In charge of exhibit: H. S. Sidebottom, F. E. Dodge, R. O. Phillips, C. P. Brown, W. W. King, R. P. Dunning, W. B. Rogers and W. E. Lupe.

BEACH-RUSS CO.—Vacuum pumps, pressure blowers, oil pumps, acid pumps, gas boosters, pebble mills, rotary cutters and laboratory mills, featuring high-vacuum pumps guaranteed to exhaust to within $\frac{1}{10}$ in. of barometer. In charge of exhibit: C. A. Beach, H. C. Russ and W. S. Ransom.

CHRISTIAN BECKER, INC.—Chainomatic balances, featuring specific gravity chainomatic balance, which has only recently been placed on the market. With this balance determinations are speedily made and readings are taken directly from the graduated scale, the Vernier reading to the fourth decimal place. Model No. 100 has a range of 0.400 to 2.000. In charge of exhibit: A. T. Millroy, D. Taylor, S. W. Hess and William L. Ferdon.

BECKLEY PERFORATING CO.—Perforated material of various descriptions and electrically welded tanks and specialties. In charge of exhibit: Otis Wright and Allen Price.

BEIGHLEE ELECTRIC CO.—(See Cleveland Instrument Co.).

BENJAMIN ELECTRIC MFG. CO

BLACKMER ROTARY PUMP CO.—A special unit for use in chemical plants consisting of a rotary pump mounted on cast iron sub-base and direct-connected to an electric motor, the complete unit being mounted on swivel casters, so that it can be moved from one part of the factory to another, in this way taking the place of several units. The pumps are provided with an automatic feature for taking up wear and removable linings, which can be changed in a few minutes. In charge of exhibit: J. H. Oldham and Arthur J. Schmitt.

BLAIR, CAMPBELL & MCLEAN, INC.—A small size patent centrifugal gas and vapor scrubber so constructed that the inside mechanism can be readily inspected. In charge of exhibit: B. Dunglinson and A. C. Wood.

BOUND BROOK CHEMICAL CO.

BOYER OIL CO.—Samples of the different oils and oil cake meals manufactured by the company. In charge of exhibit: Mr. Carper.

THE BRISTOL CO.—Recording and indicating instruments for pressure, temperature and electricity. In charge of exhibit: H. G. Hall.

THE BROWN INSTRUMENT CO.—A complete line of high and low temperature measuring instruments, including indicating and recording thermometers and pyrometers for use in the chemical industry and for the control of high-temperature processes. Brown resistance thermometer for low temperature work. Indicating and recording pressure gages for air, vacuum, oil, water, draft, etc. Indicating and recording tachometers. In charge of exhibit: R. P. Brown, G. W. Keller, J. W. Lazear, F. C. Mahoney, R. E. Soules, S. W. Thal and Richard Guest.

BROWN PORTABLE CONVEYING MACHINERY CO.—Two of the latest designs: a portable belt conveyor for handling loose materials and a portable tiering machine, the "Handilift." This last machine has three speeds and the brake is quick-acting and foolproof. The belt conveyor will handle any form of loose material and has an ingenious scoop or shovel end which allows the material to be scraped on to the belt. In charge of exhibit: Harwood Frost and Elmer D. Bushnell.

BUFFALO FOUNDRY & MACHINE CO.—Chemical apparatus: Vacuum driers of various types, including a vacuum drum drier in operation; evaporators, featuring a special type rapid circulation evaporator; kettles, autoclaves, caustic pots, nitrators, etc. In charge of exhibit: E. G. Rippel and others.

BUTTERWORTH-JUDSON CORP.—Mill dyeings of chrome colors on men's wear and dress goods; also a complete set of raw stock dyeings. In charge of exhibit: W. H. Clark and Edward A. MacKinnon.

CANADA CARBIDE CO.—Samples of carbide, showing the various sizes in which it is manufactured for domestic and foreign trade. In charge of exhibit: H. E. Mussett.

CANADIAN ELECTRODE CO.—Special features will be a 17-in. round amorphous carbon electrode and a 16 by 16 in. square amorphous carbon electrode, each approximately 5½ ft. long. In charge of exhibit: H. E. Mussett.

CANADIAN ELECTRO PRODUCTS CO., LTD.—Synthetic organic products derived from acetylene, including glacial acetic acid, paraldehyde, aldamine, acetaldehyde, acetic anhydride. In charge of exhibit: V. C. Bartram.

CANADIAN NATIONAL RAILWAYS.

THE CARBORUNDUM CO.—Carborundum refractories, including carbofrax and refrax brick, tile, muffles, tubes; carborundum refractory cement; carbofrax saggers, firesand; silicon metal; carborundum and aloxite wheels, paper and cloth. In charge of exhibit: Otis Hutchins, M. L. Hartmann, S. C. Linbarger and C. E. Hawke.

CARNOTITE REDUCTION CO.

CARRIER ENGINEERING CORP.—A complete operating installation of Carrier humidifying equipment, including the humidifier, fan and motor and automatic control instruments regulating the air delivery. The fan outlet will be provided with a diffuser so that the effects of the humidifier can be observed by noting the condition of the effluent air. In charge of exhibit: E. P. Heckel, H. B. Matzen and J. E. Bolling.

CELITE PRODUCTS CO.—Demonstrations and illustrations showing the use of Sil-O-Cel for heat insulation in various industries and also various applications of Filter-Cel, a material used for filtering various liquids. Typical uses of Celite, a light weight mineral filler, will also be illustrated. In charge of exhibit: P. A. Boeck, Thomas G. Lee, A. W. Knight and others.

CELLULOID ZAPON CO.—Unlimited color range of Zapon air drying enamels will be shown on merchandise as small as beads and as large as furniture. Silverware and highly polished metal will portray the value of Zapon air drying lacquer. Various types of products requiring a dipped or sprayed finish will also be shown. In charge of exhibit: Frank P. Davis, and representative from the New York office.

CENTRAL SCIENTIFIC CO.—DeKhotinsky constant temperature drying ovens, incubators, water baths and thermostats. The Cenco-Nelson high vacuum pump, Cenco hydrogen ion determination apparatus, Cenco electric heater for gasoline distillation, duNouy surface tension apparatus, gas analysis apparatus of various types. In charge of exhibit: S. L. Redman, A. B. Carter, S. R. Evans, E. C. Leamon and others.

CHALLENGE CO.—(See Tower and Wooden Tank Industrial Council).

CHEMICAL CONSTRUCTION CO.—Detailed plans of acid plants. Materials used in acidproof masonry construction and a model acid tower built of acidproof brick and cement showing interior construction. In charge of exhibit: T. C. Oliver and R. L. Rutzler.

CHEMICAL EQUIPMENT CO.

CHEMICAL FOUNDATION, INC.

CHICAGO PNEUMATIC TOOL CO.—Simplate valve air compressor, electrically operated; Boyer pneumatic hammers; pneumatic, riveting, chipping, calking and scaling hammers; Little Giant pneumatic and electric drills and grinders; "Hummer" and valveless type rock drills, etc. In charge of exhibit: W. P. Pressinger, H. L. Dean, T. J. Hudson, C. B. Coates and others.

ANTOINE CHIRIS CO.—A comprehensive line of essential oils and synthetic chemical products; exhibit of successive steps in the manufacture of selected products from the raw materials; Capes viscose as applied to various types of packages. In charge of exhibit: G. F. Richmond.

THE CLEVELAND-CLIFFS IRON CO.—Materials obtained from wood by the wood carbonization process, including methyl alcohol, acetone and acetic acid. In charge of exhibit: Charles B. Hall.

THE CLEVELAND INSTRUMENT CO., successor to the BEIGHLEE ELECTRIC COMPANY, INC.—Recording and indicating pyrometer equipment of both resistance and thermo-electric type, the latter using a patented compensating feature which takes care of variations in the cold junction of the thermocouples thus obviating the necessity of expensive lead wires and burying the cold junction. In charge of exhibit: W. H. Chappel.

CLINCHFIELD PRODUCTS CORP.

CONTACT PROCESS CO.—Sulphuric acid, muriatic acid, mixed (nitrating) acid, nitric acid, salt cake, etc. In charge of exhibit: E. R. Henderson, Dr. von Rucker and Truman Smith.

COORS CHEMICAL PORCELAIN CO.

CORNING GLASS WORKS—Glass laboratory apparatus made of pyrex glass. In charge of exhibit: G. Willis Drake, Irving B. Cary, F. F. Pfeiffer and F. Kraissl.

CRANE CO.—A complete line of valves and fittings for handling of steam, air, gas and water in chemical plants; electrical temperature control valve for maintaining constant temperature; working exhibit of Cranetile traps for handling condensation under low and high pressure. In charge of exhibit: Edmund Burke, W. L. Goddard, F. E. McCreary, W. A. Dallach, R. M. Miller and W. F. Lambin.

CRANE PACKING CO.—"John Crane" flexible metallic packing in coil and ring form—a packing suitable for steam, air, ammonia, sulphuric acid, and which can be used in the form of gaskets on condensers and evaporators. In charge of exhibit: F. E. Payne, H. W. Lamb, K. M. Bickel.

A. DAIGGER & CO.—Standard chemical equipment with special chemicals and equipment developed to meet the recent necessities. In charge of exhibit: Charles Rascher and R. I. Wishnick.

THE J. H. DAY CO.—Special mixing machines for powders, paste and heavy masses; also grinding machinery. In charge of exhibit: C. F. Cone and F. M. Dudley.

THE DELAVAL SEPARATOR CO.—DeLaval oil purifier, varnish clarifier, yeast separator, blood albumen separator, centrifugal filter and gasoline purifier. With each machine there will be an exhibit of the materials handled by the machine showing the different stages from raw material to finished product. In charge of exhibit: H. C. Beckman, H. M. Beach, C. F. Meissner, A. Alexander and others.

THE DENVER ENGINEERING WORKS CO.—Ruth counter current flotation machine and the Richards pulsator jig, with working models in operation. In charge of exhibit: Alfred Tellman and Joseph P. Ruth.

THE DENVER FIRE CLAY CO.—A full line of fire clay specialties; new large-size melting crucible; low-pressure fuel oil furnace, oil crushers, samplers, sieves, and a complete set of the Lind interchangeable electroscope. In charge of exhibit: L. W. Hoshour and George W. Lindsay.

DETROIT ELECTRIC FURNACE CO—A 500-lb. Detroit electric furnace for non-ferrous metals. In charge of exhibit: E. L. Crosby, A. E. Rhoads, H. M. St. John, M. G. Carhart and George B. Cross.

THE DETROIT RANGE BOILER & STEEL BARREL CO.—A complete line of Detroit drums and Perfect metal bilge barrels, the latter being in two styles, a tight package for shipment of liquids of a volatile nature and a package with a removable head which is designed for shipment of solids or semi-solids. In charge of exhibit: E. W. Sanborn and A. L. Lindeblad.

J. P. DEVINE CO.—Chemical apparatus such as chemical kettles, autoclaves, carbonators, small vacuum drying chambers (which will serve to illustrate the features of the large vacuum driers), motor-driven vacuum pumps. THE KEK MANUFACTURING CO., a subsidiary, will exhibit the Kek grinding and pulverizing mill in two sizes. In charge of exhibit: J. P. Devine, C. P. Devine and George Galloway.

DIAMOND STATE FIBRE CO.—A general line of fiber sheets, rods and tubes, together with special parts such as gears, gaskets, combs, etc. Protective paper: greaseproof, vegetable parchment, parchmoid, glassine and filter paper. In charge of exhibit: Theodore Herkert and B. M. Lewis.

DINGS MAGNETIC SEPARATOR CO.—Several types of magnetic separators; Type "M" No. 1 unit, magnetic pulley type separator, standard Wetherill high intensity unit. The two former are used for extracting strongly magnetic material from chemical products, and the Wetherill machine is applied very successfully to the concentration of minerals, chemicals, etc. In charge of exhibit: R. A. Manegold, E. S. Hirschberg and G. H. Fobian.

DOMINION WATER POWER BRANCH.

THE DORR CO.—The Dorr tray thickener, the Dorrco pump and Dorr bowl classifier will be shown in closed circuit operation on a semi-commercial scale demonstrating their application in a typcial problem of separating and dewatering two products of different physical character. Samples of materials handled with or produced by Dorr equipment will also be shown. In charge of exhibit: H. N. Spicer, C. Lee Peck, F. F. Peters, P. M. McHugh, E. R. Ramsay and G. W. Repetti.

THE DOW CHEMICAL CO.—Samples of the 86 products manufactured by the company will be shown, duplicate samples being provided with loose stoppers for convenience in closer examination. Two new products will be shown, phenyl-ethyl-alcohol and di-phenyl-oxide. The oxychloride cement floor will be demonstrated in one corner of the booth and by means of an abrasive machine the wearing qualities of this type of flooring will be compared with those of the ordinary concrete floor. In charge of exhibit: D. A. Newland and R. K. Snow.

P. W. DRACKETT & SONS CO.

DRAPER MFG. CO.

DRYING SYSTEMS, INC.

DUNCK TANK WORKS. — (See Tower and Wooden Tank Industrial Council).

DURIRION CASTINGS CO.—Acidproof equipment, including pumps, fans, ejectors and pulsometers, improved type condensers, concentrators for sulphuric and other acids, mixing kettles, denitrator towers and a full line of standard Duriron pipe and fittings. In charge of exhibit: Pierce D. Schenck, Joseph Dart, Jr., R. F. Schmidt, G. A. Cocup, J. W. Swaren, E. A. Suverkrop and R. H. B. Elkins.

EAGLE TANK CO.—(See Tower and Wooden Tank Industrial Council).

EASTMAN KODAK CO.—Research organic chemicals for university laboratories. In charge of exhibit: I. N. Hultman, Miss Anne W. Davis and Miss Ethel Schram.

ECONOMIC MACHINERY CO.

ECONOMY ENGINEERING CO.

EDGAR BROS CO.

THE EGYPTIAN LACQUER MFG. CO.—A comprehensive and varied line of finished articles showing application of lacquers, thinners, enamels and similar products. In charge of exhibit: G. W. Griffiths, Nathan P. Hunter Simeon Smith and G. J. Henry.

EIMER & AMEND—A general line of laboratory apparatus with several new laboratory specialties as well as improved types of standard apparatus. In charge of exhibit: C. G. Amend, W. R. Eimer, T. M. Saulters, L. E. Fluger and F. C. Eibell.

THE ELECTRIC FURNACE CO. — Baily electric furnace of standard type melting copper together with specimens of the wide range of products that are being melted in American foundries in this furnace. In charge of exhibit: T. F. Baily, R. F. Benzinger and F. J. Peterson.

ELECTRO BLEACHING GAS CO.—Chlorine control apparatus, containers for transporting chlorine gas, and samples of textile fabrics bleached and finished by the use of liquid chlorine. THE NIAGARA ALKALI CO. will have an exhibit in the same booth consisting of small samples of various alkali products, including caustic soda and potash.

ELECTROLYTIC ENGINEERING CO.

ELECTRON CHEMICAL CO.—A model size of the 12/1500 amp. Allen-Moore cell, together with the latest addition to the Allen-Moore cell family; namely, the 50-amp. size. In charge of exhibit: Mr. Kent, R. Fox and H. D. Marsh.

G. H. ELMORE — Acidproof centrifugal pumps. These pumps are made of two distinct types for non-corrosive metallic alloys; the first recommended for use with acids such as acetic, formic, hydrofluoric, sulphuric, etc., and the second for nitric, hydrochloric, chromic and mixed acids, ammonium hydroxide, etc. In charge of exhibit: G. H. Elmore and A. C. Wood.

THE ELYRIA ENAMELED PRODUCTS CO.—Three new pieces of apparatus which have been developed recently: A 48-in. complete still, 250 gal. capacity; an 18-in. still, 10 gal. capacity, and a 100-gal. evaporating dish which is 60 in. in diameter and 24 in. deep. In charge of exhibit: J. E. Simpson, D. M. Webster, Fred B. Morris, W. E. Gray, E. P. Poste, R. F. Goerke and Max Donaver.

CHARLES ENGELHARD — Engelhard Le Chatelier pyrometers, platinum electric resistance thermometers, electric resistance type furnaces, transparent quartz glass, Impervite refractories and porcelains. In charge of exhibit: E. S. Newcomb.

EVERLASTING VALVE CO.—Everlasting valve and Wilson cup valve. The effect of dilute sulphuric acid on various metals will be demonstrated in order to make a comparison with Aterite, a metal which is being used to make valves for certain acid work. In charge of exhibit: E. N. Corning and Ernest G. Jarvis.

FANSTEEL PRODUCTS CO., INC.

W. L. FLEISHER & CO., INC.—Model of air conditioning apparatus similar in design to that recently installed in several large plants. Model of driers for mineral, vegetable and animal products, together with samples of products dried in these machines. Models of typical power plant installations, direct and blast heating systems, ventilating layouts, and general layouts for industrial plants. In charge of exhibit: W. L. Fleisher, A. W. Dissauer and R. E. Keyes.

FOAMITE FIREFOAM CO.—A model of an oil refinery showing the efficiency of this method of extinguishing oil fires; a 40-gal. model "F" engine; 5-gal. steel extinguishers; 3-gal. approved Foamite fire pails; 2½-gal. approved copper Foamite firefoam extinguishers and recharges. In charge of exhibit: G. B. James and A. E. Canaday.

FOOTE MINERAL CO.—Display of unusual ores, rare elements and ferro-alloys, together with manufactured articles into which they enter. A complete line of zirconia products with electric furnace to demonstrate the super-refractory qualities of Zirkite and Zirkonalba. In charge of exhibit: W. M. Foote, H. C. Meyer and W. A. Koenig.

THE FORESTS PRODUCTS LABORATORY, U. S. Department of Agriculture—Testing, preparation and application of various glues, particularly those used in aircraft manufacture.

THE FOXBORO CO., INC.—A new liquid level recorder with a special water seal, making it possible to use this instrument on oils and other liquids lighter than water which would naturally attack a rubber diaphragm. A new Foxboro-Heath CO_2 recorder and an automatic temperature controller will be in operation. In charge of exhibit: A. F. Mundy, F. W. Carret, Mr. Neely and Mr. Roessner.

FUEL PRODUCTS CO.

FULLER-LEHIGH CO.

WILLIAM GAERTNER & CO — Instruments of precision: Cathetometer, comparator, spectroscope, spectrometer, gas and fuel calorimeters. Universal laboratory supports, laboratory telescopes and microscopes. In charge of exhibit: William Gaertner and C. D. Miller.

WM. GARRIGUE & CO.

CHAS. F. GARRIGUES CO. — Various grades of potash from first sorts to persulphate, caustic potash sticks of the U. S. P. pure white and alcohol purified grades; caustic soda sticks; benzoate of soda and benzoic acid, U. S. P. white odorless and tasteless; stearates of zinc and aluminum, etc. In charge of exhibit: H. D. Wellman, Mr. Campbell and Mr. Anderson.

GARY CHEMICAL CO., INC.—Ortho- and para-nitrotoluol. Ortho- and para-toluidine. In charge of exhibit: V. U. Young and Roger N. Holcomb.

GENERAL AMERICAN TANK CAR CORPORATION — Photographs and drawings of tank cars. In charge of exhibit: Hugh Epstein, Ralph Epstein and Joseph Epstein.

GENERAL BAKELITE CO.—A full line of Bakelite applications, including Bakelite varnish, lacquer, enamel, cement, transparent and colored material, molded parts, sheets, rods and tubes. A small Bakelite molding press will be in operation to show the fabrication of the material from the raw state to the finished article. In charge of exhibit: Hylton Swan, Herbert S. May, William S. Gordon, Jr., and L. M. Rossi.

GENERAL CERAMICS CO.—Small models (averaging about 10 in. in height) of practically all of the acidproof stoneware containers, machines, etc., manufactured by this company. These models are exact reproductions of standard apparatus so that visitors will have an opportunity to inspect a complete line of acidproof stoneware. In charge of exhibit: Percy C. Kingsbury.

GENERAL CHEMICAL CO.—Standard acids and chemicals, also Ryzon baking powder and Orchard Brand insecticides and fungicides. A number of products manufactured by customers of the company will be shown, such as tin plate, glues, dyes, explosives, fertilizers, artificial leather, celluloid, pharmaceuticals, etc. In charge of exhibits: N. Peterkin and George P. Adamson.

GENERAL ELECTRIC CO.—A model of the Cottrell precipitation outfit used by the Gellert Engineering Co. for recovering potash from blast-furnace gases will be shown in operation. A KT-312-6-15-hp., 1200-r.p.m., 440-v. motor with frame and coils completely coated with an acid-resisting insulation, which is particularly adapted for use in chemical and fertilizer plants. A RC-24, 2-hp., 1150-r.p.m., 230-v. totally enclosed DS-2 shunt wound motor equipped with new Arguto plug bearings. In charge of exhibit: Chester T. McLoughlin, Raymond Barclay and other representatives.

GENERAL FILTRATION CO., INC.—Acidproof Filtros filter plates in various sizes, shapes and grades; electrofiltros acidproof diaphragms for electrolytic work; acidproof cement. In charge of exhibit: F. E. Leiby and W. W. Robacher.

GENERAL FIRE EXTINGUISHER CO. — The Grinnell automatic sprinkler will be installed in a large wire-glass house in which a fire will be started once every hour to show the automatic action of the sprinkler system in extinguishing a fire. The working principle of the sprinkler head will be demonstrated by a large working model 3 ft. high. In charge of exhibit: Frank V. Sackett, Howard E. Branch, Theodore Fertig, John G. Thomas, A. E. Gauslin, H. D. MacDonald, H. H. Duley, H. O. Booth, S. Dorais and J. F. Gilmore.

GLAMORGAN PIPE & FOUNDRY CO — Models of continuous gas-fired limekiln and causticizing tower. Improved rotary continuous suction filter in operation. Caustic flaker in operation. In charge of exhibit: W. D. Mount and C. H. Himnant.

GLENS FALLS MACHINE WORKS — Pulp and paper machinery, including Glens Falls rotary sulphur burner, Woods thickener machine for guncotton and chemical pulp, and the new split-cam for quick repair work on screens. In charge of exhibit: James H. Haines and others.

GORDON DRYER CORP.—"AA" size Gordon high-efficiency atmospheric drier. This size has grown very popular among colleges and research laboratories, as it is an ideal type of unit for small batch production. There will also be on exhibition a "D" drier, this unit containing 500 sq.ft. of effective drying surface. Both outfits will be complete so that drying tests can be made for any interested customer. In charge of exhibit: Nathan Owitz, R. R. James, H. D. Harvey and Richard B. Hewitt.

GOULDS MFG. CO.

GROCH CENTRIFUGAL FLOTATION, LTD.—A new model flotation machine in which the impeller acts as a centrifugal pumps, sucking air and oil through a hollow shaft. On striking the impeller blades the oil is broken up into small bubbles and thoroughly mixed with the solution, giving ideal flotation conditions. In charge of exhibit: Frank Groch, N. C. Groch and T. Garster.

GRUENDLER PATENT CRUSHER & PULVERIZER CO.

THE GUERNSEY EARTHENWARE CO.—Chemical laboratory porcelain: Crucibles, filter plates, casseroles, combustion capsules, evaporating dishes, beakers, concentric rings, filter rings, dye pots, funnels, desiccator plates, combustion tubes, porous cells, etc. In charge of exhibit: Allan L. Goulding.

HAMILTON & HANSELL, INC.—A 500-lb. Rennerfelt furnace of the type which has been widely used in steel making and in the melting of ferrous and non-ferrous alloys. In charge of exhibit: H. A. DeFries and Thomas Hagelthorn.

HANOVIA CHEMICAL & MANUFACTURING CO.—Laboratory apparatus of pure transparent quartz glass featuring very fine quartz fibers for instrument suspension and special vacuum discharge tubes for rare gases. Platinum wound electric laboratory furnaces. Direct reading electric resistance thermometers for central station industrial temperature control. Quartz mercury vapor lamps for research work with ultra-violet rays. In charge of exhibit: E. W. Fisher.

HARDINGE CONICAL MILL CO. — An exact model of the Hardinge conical ball mill will be in operation. Large users of the Hardinge mill will be featured by name and photographs of their installations will be shown. In charge of exhibit: Captain Harlowe Hardinge.

HAUSER-STANDER TANK CO.—See Tower and Wooden Tank Industrial Council).

HAYNES STELLITE CO.

FRANK HEMINGWAY, INC.

S. S. HEPWORTH CO.—Centrifugals of all types in operation including a large electrically driven two-speed centrifugal capable of handling five tons of material per hour; water-driven centrifugal; Macintosh ball-bearing centrifugal and an under-driven machine, suitable for products in small quantities or where there are fumes requiring the top to be sealed. Hand-operated and power-driven unloaders. In charge of exhibit: Bruno C. Lechler, C. A. Olcott and E. F. Babbitt.

HERCULES ENGINEERING CORP.—A nitrator and an autoclave, having certain distinctive features which should be of interest to operators whose work requires equipment of this sort. Interesting information on Hercules evaporators, concentrators and equipment for the generation, compression and liquefaction of gases. In charge of exhibit: R. D. Kehoe, A. R. Calvo, W. H. Campbell, T. J. Brewster and Richard Neuhaus.

HERCULES POWER CO.—A complete line of organic chemicals including organic acids, valerates, pyroxylin solutions, waterproof cements, soluble cotton and solvents. The special features will be sodium alginate (Algin No. 3). which is being used as a sizing material for split leather, leather cloth and other fabrics. In charge of exhibit: G. C. O'Brien and W. L. Holter.

HEROLD CHINA & POTTERY CO.

J. D. HOLLINGSHEAD CO.

HOOD, B. MIFFLIN, BRICK CO.

HOOKER ELECTROCHEMICAL CO.

HOSKINS MANUFACTURING CO.—Laboratory electric furnaces, hot plates and thermo-electric pyrometers of the indicating and recording types, featuring a new multiple recording pyrometer, which will be in operation. In charge of exhibit: C. F. Busse, W. D. Little and C. S. Kinnison.

HUFF ELECTROSTATIC SEPARATOR CO.—A half-size electrostatic separator operating with samples of various minerals, showing separation of copper and tin from tungsten, ilmenite from sand, rutile from zircon, lead from barytes, etc. Plumb pneumatic jig, laboratory size, which is a dry process and for that reason is particularly adapted to the concentration of ores where water is scarce. In charge of exhibit: H. B. Johnson, F. R. Johnson, C. D. Burrage, Jr., and William E. McKee.

THE HUNTER DRY KILN CO.—Models of automatically controlled humidity driers as well as samples of various materials dried by this system. In charge of exhibit: Harry Hunter, O. M. Ragsdale and Arthur B. Stonex.

HYCO FUEL PRODUCTS CORP.

IDEAL STENCIL MACHINE CO.—Stencil machines for cutting paper stencils for marking shipments, stencil filing cabinets, stencil ink and other shipping-room supplies and equipment. In charge of exhibit: G. E. Berglund and J. W. Marsh.

INDUSTRIAL ELECTRIC FURNACE CO.

INDUSTRIAL FILTRATION CORPORATION—Open tank type of filter, rotary hopper dewaterer and the continuous rotary filter. In charge of exhibit: G. D. Dickey and H. B. Faber.

INNIS, SPEIDEN & CO.

IRVING IRON WORKS CO.—A platform consisting of different sizes of Irving-Subway recticuline grating, with stairways showing Irving safety steps. In charge of exhibit: W. E. Irving, P. L. Price and F. N. Dodge.

JEWELL POLAR CO.—Steam operated still together with storage tank in operation. Steam, gas and electric laboratory stills. In charge of exhibit: A. C. Jewell, R. E. Henry, J. E. Bloeser and George Hild.

JOHNSON & CARLSON—(See Tower and Wooden Tank Industrial Council.)

KEK MFG. CO.—(See J. P. DEVINE CO.)

KENART SYNTHETIC PRODUCTS CO.—Numerous synthetic perfume and flavor bases, among them several not previously manufactured in this country; several pharmaceutical products; synthetic and vegetable food colors and dyes. In charge of exhibit: S. Wilmer Kendall and Hugh S. Stewart.

KEWAUNEE MFG. CO.—Laboratory fixtures: Chemical case (919); fume hood (933); chemistry desks (895 and 939); dark-room desk (1424); peg board (1434); exhibit case (1460); combustion table (909). In charge of exhibit: F. H. Wiese, R. A. Hanna, William E. Mix, O. T. Louis, F. M. Hassett and R. G. Siple.

MAURICE A. KNIGHT—A full carload of large standard and special pieces of chemical stoneware apparatus, as well as several complicated and small pieces. In charge of exhibit: Maurice A. Knight, Charles Dennison, Percy Sawyer and Samuel J. Baril.

THE KOPPERS CO.—One of the features will be a display of coke and by-products in the proportions produced in the coking of Illinois coal in Koppers ovens, based on official records of the U. S. Bureau of Standards. A new type of by-product coke oven exhibited for the first time. Model of the Koppers by-product coke oven. In charge of exhibit: E. L. Crowe and E. H. Bird.

LAMMERT & MANN CO.—Several sizes and styles of rotary dry vacuum pumps, some of which will be in operation. In charge of exhibit: Donald Rosie, Lawrence Eisenbies and R. F. Lammert.

LEAD LINED IRON PIPE CO.

LEEDS & NORTHRUP CO.—Different forms of apparatus—some of which will be shown in operation—for electrically determining the acidity or alkalinity of solutions. Equipments for electrolytic conductivity measurements, and an automatic recorder, which can be applied to recording changes in any process in which such changes are accompanied by changes in electrolytic resistance. Hand-operated and automatic recording potentiometers for temperature measurements of various ranges; a White combination potentiometer for precision thermocouple measurements; an optical pyrometer for accurate determinations of high temperatures, above the range of thermocouples; and other forms of apparatus of interest to chemists. In charge of exhibit: Paul E. Klopsteg, I. Melville Stein, G. W. Tall, Jr., H. Brewer and O. Brewer.

LINDSAY LIGHT CO.

THE LIQUID CARBONIC CO.—A working exhibit demonstrating the methods and apparatus used to adapt CO_2 to such pressures and temperatures as are required for its use in commercial processes. Complete outfits for large and small users, pressure regulators and tempering coils for CO_2, oxygen, acetylene and other gases. In charge of booth: J. H. Pratt, E. D. Hale, W. S. Hopkins and R. D. Crisp.

ARTHUR D. LITTLE, INC.—Pictures of the firm's building and laboratories, with pamphlets describing the facilities for solving problems of applied chemistry. In charge of exhibit: H. L. Sherman and Clarence J. West.

LUNGMOTOR CO.

EMIL E. LUNGWITZ—A Kelly filter press, type 150, made of steel and iron, and a type 30 press, made of copper throughout. In charge of exhibit: Emil E. Lungwitz, H. L. Dick and Wm. D. Neuberg.

THE LUNKERHEIMER CO.

MACBETH-EVANS GLASS CO.—Representative samples of laboratory glassware. In charge of exhibit: F. K. Pinckney and J. F. Humez.

MACHINERY UTILITIES CO.

MAGNETIC MANUFACTURING CO.—Magnetic pulley separator for separating iron from various sorts of materials. Type "L", No. 4, magnetic separator for separating iron from brass, aluminum and bronze turnings and other fine material. High intensity laboratory type for separating feebly magnetic materials such as ores, abrasive materials, etc. In charge of exhibit: J. P. Bethke.

MANN & COOK.

MARDEN, ORTH & HASTINGS CORPORATION—Dyes and intermediates manufactured by the Calco Chemical Co. Processed fish oils for the paint and varnish industries. Tanning oils, moellons and extracts. Samples of results obtained by using these various products. In charge of exhibit: Mr. Breuer and Mr. Johnston.

MARIETTA REFINING CO.—Malachite green; from raw products to finished crystals, some of these weighing 42 lb. each. About 150 different articles dyed or colored with malachite green. In charge of exhibit: H. C. Phelan.

THE MATHIESON ALKALI WORKS, INC.—Caustic soda, soda ash, liquid chlorine, bleaching powder and other Eagle-Thistle brand heavy chemicals. Solvents, including tetrachlorethane, ethylene chloride and similar products. In charge of exhibit: Adriaan Nagelvoort, Otto A. Fritz and H. D. Winship.

MEAD & CO.—Mead mills. In charge of exhibit: Paul O. Abbe and staff of Paul O. Abbe, Inc.

MERCK & CO.—Emphasis will be placed on the exhibit of medicinal chemicals, particularly those developed since the outbreak of the war, such as bismuth salts, iodine and iodides, salicylates, salol, synthetic oil of wintergreen, etc. Chemical reagents of a high standard of purity.

THE MERRILL CO.—The Nordstrom lubricated plug valve, which is so constructed that, in case the valve sticks, the plug can be lifted from the seat, insuring proper lubrication of the bearing surfaces. In charge of exhibit: C. C. Broadwater, L. D. Mills and S. J. Nordstrom.

METALS DISINTEGRATING CO., INC.—Lead powder for carbon brushes and storage batteries. Tin powder for coated papers and carbon brush industry. Bronze powders for decorative purposes. Aluminum powder for fire works and calorizing. Copper powders for dye works and sherardizing. In charge of exhibit: S. G. Schatzberg.

MINER, EDGAR CO.

MIDWEST ENGINE CO.

MINE SAFETY APPLIANCES CO.

MOJONNIER BROS. CO.—Mojonnier laboratory specialties: moisture testers, vacuum pumps, viscosimeters, extraction flasks and other laboratory glassware and accessories. In charge of exhibit: T. Mojonnier, J. J. Mojonnier, R. Moon, P. C. Mojonnier and F. D. Courtenay.

MONSANTO CHEMICAL WORKS

J. L. MOTT IRON WORKS—Apparatus with acid-resisting enamel such as laboratory antoclaves (one to 5 gal.), crystallizing pans and a complete distilling unit with vacuum still, condenser and container. In charge of exhibit: J. J. Blackmore and R. J. Shively.

NASH ENGINEERING CO.—Nash Hytor air and gas compressors, Nash Hytor vacuum pumps, and Jennings Hytor vacuum heating pumps, assembled and in actual operation and apart for inspection. In charge of exhibit: Irving C. Jennings, Howard M. Wylie, and G. B. Wright.

NASSAU VALVE & PUMP CORP.—"Chemetal" acid-resisting valves and horizontal centrifugal pumps. In charge of exhibit: E. J. Walsh, Henry A. Born, H. M. Pier and A. T. Haviland.

NATIONAL ANILINE & CHEMICAL CO.

NATIONAL FILTER CLOTH & WEAVING CO.—Cotton filter cloth, which is specially constructed for filtering purposes, hence more advantageous to use than ordinary duck. In charge of exhibit: M. W. Smith and Edward Boffin.

NEWARK WIRE CLOTH CO.—A full line of wire cloth, sieves, filter cloths, etc. A high-power microscope will show the construction of patented filter cloth. In charge of exhibit: Alvin Allen Campbell.

NEW JERSEY ZINC CO—Zinc oxides as used in high-grade paints. Slab zinc (spelter) in various grades, including the well-known "Horse Head" brand. Rolled zinc, lithopone, zinc chloride, sulphuric acid, muriatic acid, salt cake, spiegeleisen and zinc dust. In charge of exhibit: F. C. Ryan.

NEWPORT CHEMICAL WORKS, INC.—The various steps in the manufacture of dyes from "coal to dyestuff" will be shown. In charge of exhibit: John W. Kopf and Giles Low.

NIAGARA ALKALI CO.—(See Electro Bleaching Gas Co.).

NIAGARA ELECTRO CHEMICAL CO.

NITROGEN PRODUCTS CO.—Sodium cyanide and other chemicals made by their synthetic process. In charge of exhibit: Adriaan Nagelvoort, H. D. Winship and Otto A. Fritz.

THE NORTHWESTERN CHEMICAL CO.—Synthetic flavors; butyrates, butyl acetate, amyl formate, caproic acid, valeric acid and valerates. In charge of exhibit: Robert L. Wilson and Miss H. M. Allen.

THE NORTON CO.—Alundum and crystolon refractories, laboratory ware and refractory cement, electrically sintered magnesia. Samples of ignition capsules, combustion boats, filtering cones, electric furnace cores, extraction thimbles, pyrometer tubes, and alundum and crystolon for electric furnaces. In charge of exhibit: H. R. Savage.

THE S. OBERMAYER CO.

OHIO POTTERY CO.

THE OLIVER CONTINUOUS FILTER CO.—A 3-ft. diameter by 2-ft. face Oliver continuous filter in operation, showing distinctive features of this machine. Drum filters, a continuous and automatic Oliver horizontal filter used in products too coarse and fast settling to be handled on the drum filter. In charge of exhibit: R. G. Walker, H. A. Morrison, Paul R. Sheffer and W. Bohlman.

ONTARIO BUREAU OF MINES—Representative samples of ores and minerals from the various mineral areas in the Province, including Cobalt silver camp, Porcupine, Kirkland Lake and Boston Creek gold areas, Sudbury nickel region, etc. Feldspar, fluorspar, graphite, talc and molybdenite from eastern Ontario. Salt and salt products of the Canadian Salt Co. and soda ash from Brunner Mond Canada, Ltd., will be displayed. In charge of exhibit: W. K. McNeill and W. R. Rogers.

ORGANIC SALT & ACID CO.—Thirty Orsac products, including salicylic acid and its salts and derivatives, ortho, meta and para cresotinic acids, triphenyl phosphate, tricresyl phosphate, benzyl alcohol, benzyl benzoate and benzyl acetate. In charge of exhibit: Karl Kolbe.

PALO CO.—Meker burners and furnaces as manufactured by G. Meker & Cie., Paris; Link automatic water still; Hess-Ives tint photometer, the only instrument that will determine color values of liquids and solids by a numerical expression without involving the personal equation; Durieux filter paper; Palo absorber; Lane Laboratory burners, etc. In charge of exhibit: M. J. Seavy.

PARKS-CRAMER CO.—Parks-Cramer hot oil circulating systems. One 200,000-B.t.u. Merrill process system consisting of absorber setting and coil, motor-driven oil-circulating positive pressure rotary pump, thermostatic control apparatus and all necessary accessories. The system will be connected to a Dopp kettle. Guyton & Comfer jacketed pipe fittings. In charge of exhibit: A. W. Thompson, A. B. McKechnie and C. A. Willard.

PENNSYLVANIA SALT MANUFACTURING CO.—Heavy chemicals in large glass containers.

THE PERMUTIT CO.—A small Zeolite water softener for demonstration purposes, and photographs showing installations of various types of water-rectifying apparatus. A complete list of Permutit apparatus displayed on cards and literature describing the apparatus. In charge of exhibit: Albert Tate Smith, Benjamin M. Ferguson, Frank S. Dunham, Class Kennicott, C. A. Roberts and H. G. Taylor.

PERTH AMBOY CHEMICAL WORKS.

LEONARD PETERSON & CO., INC.—High-grade laboratory furniture to exhibit laboratory glassware and apparatus manufactured by E. H. Sargent & Co. In charge of exhibit: Leonard Peterson, O. L. Lethander and Bernard Wiest.

THE PFAUDLER CO.—A 26-gal. utility pot with accessory apparatus; a 6-gal. Milwaukee pot; a 32-gal, Milwaukee pot; a 50-gal. open jacketed tank; a 141-gal. open jacketed evaporating pan; a 500-gal. closed jacketed tank with enameled agitator; a 500-gal. closed tank. All this apparatus lined with Pfaulder acid-resistant glass enamel. In charge of exhibit: R. B. Kilmer, O. I. Chormann, W. E. Foster and H. R. Allen.

THE PHILADELPHIA DRYING MACHINERY CO.—Several working models of "Hurricane" driers for chemicals, clay and porcelain. Also collection of photographs showing installations in representative plants throughout the United States. In charge of exhibit: Walter W. Sibson, C. H. Reumann and H. C. Moore.

PHILADELPHIA QUARTZ CO.—Various grades of manufac-

tured silicate of soda, with literature on the principal uses of each grade as applied. In charge of exhibit: C. F. Wolcott, G. W. Wait and E. A. Russell.

THE PHILADELPHIA TEXTILE MACHINERY CO.—A model of a Proctor four-truck drier for paints, chemicals, colors, etc. A model of Proctor three-conveyor drier for cotton, wool, chemicals, etc. A large display of all kinds of materials dried in Proctor Research Laboratory. In charge of exhibit: E. B. Ayres, Mrs. J. C. Reiter, W. R. Murray, Joseph Tiers and W. J. Dudley.

PNEUMERCATOR CO., INC.—A working outfit illustrating the simplicity of operation of the pneumercator tank gage. Various models will be shown. In charge of exhibit: William Thomas, A. F. Kuehne and Henry Jones.

PRATT ENGINEERING & MACHINE CO.—Photographs of machinery and apparatus manufactured for the chemical and fertilizer trade, and photographs of various plants designed and erected by this company for the manufacture of sulphuric and nitric acids and fertilizers. Designs of plants for the manufacture of acid phosphate and commercial fertilizers and sulphuric acid. In charge of exhibit: George F. Hurt, G. A. Austen, E. E. Maher and C. A. Murphey.

PRECISION INSTRUMENT CO.—Carbon dioxide, sulphur dioxide, recorders, indicating draft gages (single, 2 in 1, to 5 in 1), recording gages, calorgraph, gravitometer, coal calorimeter, and other apparatus for testing and measuring gases. The precision CO_2 recorder delivers every 3 min. a definite fixed volume of flue gas, analyzes the mixture and then records on a chart the percentage of carbon dioxide present. It is accurate to within 0.5 per cent. In charge of exhibit: Charles E. Conway.

PRECISION THERMOMETER & INSTRUMENT CO.

PRESSED STEEL TANK CO.

PRODUCT SALES CO.

PROVOST ENGINEERING CORP.

PYROLECTRIC INSTRUMENT CO.—Electrical precision instruments, a-c and d-c galvanometers, electrometers, etc. A new type of lamp and scale reflection indicator, the Northrup pyrovolter, a small Northrup-Ajax high-frequency induction furnace with water-cooled induction coil, in operation. In charge of exhibit: H. F. Porter and W. C. Harter.

QUIGLEY FURNACE SPECIALTIES CO.—Temperature tests on the bonding strength of Hytempite, a highly refractory plastic material for bonding fire brick, etc. Carbosand, a highly refractory fire sand for making rammed-in linings. Insulbrix, a specially prepared cellular insulating brick for furnaces; Quigley powdered coal system for preparing, transporting and burning powdered coal. In charge of exhibit: W. S. Quigley, H. A. Kimber, W. O. Renkin, J. G. Coutant and L. G. McPhee.

RARITAN COPPER WORKS and the ANACONDA COPPER MINING CO.—By-products obtained during the electrolytic refining of copper: White arsenic, tellurium oxide, tellurium, selenium, gold, silver, platinum and palladium, nickel and copper sulphates. Lead from the International Lead Refining Co., East Chicago, Ind., high-grade electrolytic zinc from the Great Falls Refinery, "Anaconda white lead" from the Anaconda Lead Products Co., East Chicago, Ind., products of the new copper rolling mill. In charge of exhibit: S. Skowronski and H. D. Hawks.

RAYMOND BROS. IMPACT PULVERIZER CO.—Four models in operation illustrating the various types of pulverizing mills manufactured by this company, three to be one-quarter size of the actual machines and one full-size model small No. 0000 pulverizer used extensively in the chemical, dry color and dyestuff industries. In charge of exhibit: C. M. Lauritzen, W. M. Cook, S. B. Kanowitz, R. A. Lachmann and W. B. Senseman.

REDMANOL CHEMICAL PRODUCTS CO.—Cigar and cigarette holders manufactured from transparent redmanol. Demonstration of manufacture of molded parts from redmanol molding mixtures. In charge of exhibit: L. V. Redman.

REPUBLIC FLOW METERS CO.—The regular Republic flow meter, together with a recently developed flow meter for making very low differential pressures. This meter measures accurately as low as one-thousandth of an inch water differential pressure. A blower will be installed in the booth so that both meters will be operating under regular conditions. In charge of exhibit: James D. Cunningham, J. M. Spitzglass, C. R. Matheny, C. E. McGregor, J. Tigerman and T. S. Williams.

RESEARCH CORPORATION.

RESEARCH LABORATORY OF CHICAGO.

REVOLVATOR CO.—Models of revolving portable elevators. In charge of exhibit: H. S. Germond, Jr., and others.

ROESSLER & HASSLACHER CHEM. CO.

ROLLIN CHEMICAL CO.

ROSSENDALE-REDDAWAY BELTING & HOSE CO.

SARCO CO., INC.—A complete line of thermostatic steam and radiator traps, metallic gaskets and several models of standard and special temperature regulators. In charge of exhibit: Clement Wells, E. J. Ritchie, F. D. Harger, G. M. Cameron, G. F. Cordner and G. B. Burke.

E. H. SARGENT CO.—Laboratory supplies.

SCHAAR & CO.—Chemical laboratory apparatus of American manufacture, including analytical balances, electric flask heaters, etc., manufactured by this company. American-made glassware, porcelain ware and apparatus handled for other manufacturers. In charge of exhibit: Adolph E. Schaar, Eric W. Ohman, Andrew R. Stevenson and J. Gardner Goodwin.

SCHAEFFER & BUDENBERG—Pressure and vacuum gages, mercurial pressure and vacuum gages, gage testers, "Crescent" industrial thermometers, "Reform" mercury thermometers, "Columbia" mercury recording thermometers and other testing apparatus. In charge of exhibit: C. E. George, and Messrs. Parker, Coesfeld and Campbell.

JOSEPH SCHNEIBLE

SCHUTTE & KOERTING CO.—Equipment for handling chemiccal gases: automatic blowcase attachment, jet pumps, etc., used in handling of chemical liquids. Power-plant valves, spray nozzles, oil-burning equipment. In charge of exhibit: Dr. C. H. Kimberly, A. C. Nell and J. S. Patten.

SCHWARTZ SECTION SYSTEM—A sectional cabinet for filing laboratory chemicals and reagents, samples and specimens. In charge of exhibit: M. P. Schwartz.

SCIENTIFIC EQUIPMENT CO.—(See Central Scientific Co. and Kawaunee Mfg. Co.)

SCIENTIFIC MATERIALS CO.—Standard lines of laboratory glassware and porcelain. Complete line of filter papers. Special graduated and blown glassware. The new Fisher burner; museum jars; Scimatco tubing, etc. In charge of exhibit: R. H. Hix and Dr. F. L. Hinckley.

ERNEST SCOTT & CO.—Photographs showing installations made in the following industries: Oil extraction from nuts, seeds, beans, etc., by Scott's solvent process; extraction of grease from bones, packers' tankage, etc.; recovery of glycerine in soap factories and caustic soda from paper pulp spent liquors, cotton mercerizing mills, etc., by the Scott evaporator. Extraction of oil from fish and fish waste, glycol and glycerine refining plants, fatty acid distillation. In charge of exhibit: H. Austin, Robert MacGregor and C. E. Bradley.

SEMET SOLVAY CO.

THE SHARPLESS SPECIALTY CO.—Various models of supercentrifugals featuring centrifugal equipment designed for use in the separation of paraffine wax from mineral oils, together with samples of resulting oils of different crudes. In charge of exhibit: Max B. Miller, F. A. Frank, E. E. Ayres and Walter E. Cox.

SHAWINIGAN ELECTRO METALS CO.

SHAWINIGAN WATER & POWER CO.

SHERWIN-WILLIAMS CO.

B. B. SHIPPERS SUPPLY CO.

The W. W. SLY MANUFACTURING CO.—A working installation of a "Sly" dust arrester for the collection and reclamation of dust. In charge of exhibit: P. W. Graue and E. J. Moore.

WALTER SODERLING, INC.

SOLVAY PROCESS CO.

SOWERS MANUFACTURING CO.—The construction of Dopp seamless steam jacketed kettles demonstrated by a sawed-up section of a 16-gal. kettle, showing that kettle wall, jacket and staybolts are one single casting with no joints, bolts, seams or welds. A 10-gal. Dopp standard vacuum pan with sweep mixer, 150-gal. Dopp standard kettle with ribbon-type mixer and 350-gal. Dopp rectangular kettle, 8 ft. x 3 ft. 6 in. x 2 ft. deep. In charge of exhibit: R. C. Boggess and P. B. Coxe.

D. R. SPERRY & CO.—Filter presses, plates and frames made of various materials, filter press cocks and various plate surfaces. In charge of exhibit: D. R. Sperry and B. H. Conley.

THE STAR BRASS WORKS—General line of spray nozzles in operation. In charge of exhibit: H. D. Binks, B. R. Sausen and C. R. Kranz.

STEIN HALL & CO.

STIMPSON EQUIPMENT CO.

C. H. STOELTING.

F. J. STOKES MACHINE CO.—Rotary tablet machine in operation making naphthalene balls. Powder-filling machine in operation. Rotary vacuum drier, laboratory vacuum drier, vertical surface condenser, copper vacuum still, automatic water still. In charge of exhibit: L. H. Bailey and C. F. Coleman.

STRESEN-REUTER & HANCOCK, INC.

STURTEVANT MILL CO.—The "Open-Door" line of crushing, grinding, pulverizing, screening, mixing, elevating and conveying machinery. The "Open Door" will be especially featured as a labor and time saver. They swing like the door of a safe and open the interior of their various machines to more complete accessibility than can any number of parts or castings and plates, the removal of which costs so much in time wasted. In charge of exhibit: H. A. Tomlinson, L. N. Doyle, J. S. Vrabek and W. T. Doyle.

SULLIVAN MACHINERY CO.—A model air-lift pumping plant in operation, consisting of Sullivan air-lift pump, separating head, cyclone boosters, etc., electrically operated by compressed air; also samples of its acid pumps, separating heads in standard and special acid and chemical resistant material, and display photographs of installations and equipment. In charge of exhibit: John Oliphant, Howard T. Walsh, Joseph H. Brown, R. E. C. Martin and S. B. King.

SUNBEAM CHEMICAL CO.—Methylene blue, paranitrosodimethylaniline, and acid azo red, eosine, erythrosine, crude glycerine, sulphonated oils, and the dye soap "Rit." In charge of exhibit: L. C. Cates.

SWEDISH CRUCIBLE STEEL CO.—Steel castings for heat-treating processes and for resisting oxidation under high temperature. Complimentary tickets to the Exhibition of the American Steel Treaters' Society will be issued at this booth. In charge of exhibit: H. H. Harris, Mr. Van Arman and Mr. Kingsley.

SWENSON EVAPORATOR CO.—One evaporator will be in operation, and another so arranged that an examination of the internal construction can be readily made. In charge of exhibit: F. M. deBeers, P. B. Sadtler, P. H. Appell, D. C. Giles, S. W. Hind, A. H. Boehmer and F. F. Mackentepe.

C. J. TAGLIABUE MFG. CO.—"Tag" P. & W. liquid level and condensate controllers for automatically maintaining liquid levels in evaporators, closed and open tanks, etc. "Tag" self-operating and perfect automatic temperature and pressure controllers for automatically maintaining a uniform temperature or pressure regardless of a variable initial supply in coolers, driers, mixing kettles, stills, etc. "Tag" automatic combination time and temperature controller, the "Tag" absolute pressure controller. In charge of exhibit: Wallace W. White, D. M. Morgan and V. Wichum.

TANK EQUIPMENT CO.

TAYLOR INSTRUMENT CO.—Indicating and recording thermometers and pyrometers; laboratory and oil-testing instruments; pressure and temperature regulators. In charge of exhibit: Messrs. Ely, Amdursky, Schwartz, Taylor, Heyss, Pagenstecker, Lemke, Rinder, Levy, Sutherland, Drs. Clark and Hurlbert.

TECHNICAL PRODUCTS CO.

TEXAS GULF SULPHUR CO.—In charge of exhibit: J. A. B. Landell and Arthur S. Cosler.

THE THERMAL SYNDICATE, LTD.—Vitreosil products for laboratory and plant. Vitreosil is unaffected by the usual mineral acids or by sudden and extreme changes of temperature, as will be demonstrated by heating vitreosil crucibles to a temperature of approximately 1000 deg. C. and plunging them immediately into cold water. In charge of exhibit: Stephen L. Tyler and William W. Winship.

THE THERMO ELECTRIC INSTRUMENT CO. — Freas and Thelco types of constant temperature apparatus, forced air and vacuum ovens, also the latest type, the Swirl oven, in which the operator can keep his material in constant agitation while it is subjected to a constant temperature. In charge of exhibit: E. H. Heacock, J. S. LaMer and Royal B. Freas.

ARTHUR H. THOMAS CO.—Kelley electrometric titration apparatus for the determination of Cr, V, and Mn in steel and ferrous alloys. Cain electrometric titration apparatus for the determination of carbon in steel by the direct combustion method. Edwards gas density balance. Volumetric apparatus; electric drying ovens; Mandler diatomaceous filters, etc. In charge of exhibit: R. M. Miller, H. C. Roak and C. C. Roberts.

THWING INSTRUMENT CO.—Recording and indicating pyrometers for all ranges of temperature, paper testing apparatus, particularly basis weight scales, and an instrument for recording the tearing strength of paper. In charge of exhibit: Dr. Charles B. Thwing and William S. Miller.

TITANIUM ALLOY MFG. CO.

TOLHURST MACHINE WORKS—A 32-in. heavy type suspended centrifugal with bottom discharge. Motor-driven 40-in. self-balancing centrifugal. A 20-in. solid curve centrifugal and a new type 12-in. laboratory centrifugal. In charge of exhibit: John S. Gage, T. A. Bryson and T. M. Stuart.

TOWER & WOODEN TANK INDUSTRIAL COUNCIL.—The Council comprises the following companies: Challenge Co., Dunck Tank Works, Eagle Tank Co., Hauser-Stander Tank Co., Johnson & Carlson, U. S. Wind Engine & Pump Co., Wendnagel & Co. Rectangular tank, agitator, generator, film developing, crystallizing, filter tanks, tank with sloping bottom for drainage, model of sprinkler or gravity water supply tank, and burned-in lead-lined chemical tanks, each having a portion cut away so that details of construction may be studied. In charge of exhibit: Engineers of above mentioned companies.

UNION STEAM PUMP CO.

UNION SULPHUR CO.—In charge of exhibit: W. N. Wilkinson and W. M. P. Taylor.

UNION THERMOMETER CO.

UNITED FILTERS — 4-1 type American filter with direct motor drive. A No. 2 size Sweetland filter constructed of aluminum, and a small model of a Kelly unit. A small United plate and frame press exhibited for the first time. Samples of cotton and metallic filter cloth for inspection of visitors. In charge of exhibit: C. B. Oliver, J. T. Hoyt and Winslow Souther.

UNITED LEAD CO., the UNITED LINED TUBE & VALVE CO. and the RAYMOND LEAD WORKS—United lead-lined iron pipe, valves, fittings and tin-lined valves and fittings. A new line of silver-lined valves, centrifugal acid pumps, Ulco hard metal. In charge of exhibit: L. B. Gallison and C. B. Holden.

U. S. BUREAU OF MINES—Exhibits from the various field offices of the Bureau and safety devices including the army gas mask. In charge of exhibit: M. F. Leopold.

U. S. CAST IRON PIPE & FOUNDRY CO.—Photographs and samples of Usicast products. In charge of exhibit: H. A. Hoffer and J. D. Capron.

U. S. INDUSTRIAL ALCOHOL CO. and U. S. INDUSTRIAL CHEMICAL CO.—Many uses of alcohol shown on an exhibit board. In charge of exhibit: B. R. Tunison.

U. S. STONEWARE CO.—Representative pieces of standard chemical stoneware. In charge of exhibit: F. S. Wills and G. M. Wills.

U. S. WIND ENGINE & PUMP CO.—(See Tower and Wooden Tank Industrial Council).

UNIVERSAL OIL CO.

UNIVERSE CO.

VAN SCHAACK BROS. CHEM. WORKS.

VALLEY IRON WORKS, Appleton, Wis.—A small Vesuvius sulphur burner, a laboratory beating engine and a centrifugal acid-resisting pump. In charge of exhibit: W. H. Burns and R. A. Peterson.

VALLEY IRON WORKS, Williamsport, Pa.—A line of laboratory autoclaves ranging from 2¾-qt. to 5½-gal. capacity and built for operating pressures up to 1000 lb. per sq.in. In charge of exhibit: R. L. Riley and Thomas Senior.

VIRGINIA SMELTING CO.

THE VITREOUS ENAMELING CO.—A full line of Vitreous enameled pans and trays. In charge of exhibit: Harry Warman and Charles E. Bullard.

WALLACE & TIERNAN CO.

WEDGE MECHANICAL FURNACE WORKS.

WENDNAGEL & CO.—(See Tower and Wooden Tank Industrial Council).

WERNER & PFLEIDERER CO. — Laboratory mixers and grinders. In charge of exhibit: Emil Staehle, J. C. Caley, C. Pletscher, S. D. Gridley, H. Gronbak and H. E. Gregor.

WESTERN RESERVE CHEMICAL CO.

WESTINGHOUSE ELECTRIC & MANUFACTURING CO.—Industrial motors and control devices, fans, meters, heating appliances, circuit-breakers and switches.

WHITALL TATUM CO.—Chemical glassware and laboratory apparatus. In charge of exhibit: J. F. Matthes.

J. G. WHITE ENGINEERING CORP.

THE WHITLOCK COIL PIPE CO.—Working model showing the application of exhaust steam in heaters adapted to the chemical industries. In charge of exhibit: R. S. Bull, J. E. Chubb and E. B. Cole.

THE WIDNEY CO.—The Widney modulimeter for testing materials from steel to felt, rubber, paper, leather, etc. In charge of exhibit: S. W. Widney.

WILSON-MAEULEN CO.—Indicating and autographic pyrometers, especially the multiple record tapalog and dust and fume proof pyrometer switches. In charge of exhibit: C. J. Brown, G. V. Nightingale and F. C. Baker.

ZAPON LEATHER CLOTH CO.

ZAREMBA CO.—Photograph and drawings of evaporator installations in many kinds of service in the chemical industries. In charge of exhibit: Edward Zeremba, W. H. Eggert, H. E. Jacoby and B. S. Hughes.

ZAVON, INC.

Natural and Industrial Resources of the North Central States

The natural resources of that group of North Central States comprising Illinois, Indiana, Michigan and Wisconsin are marked by both variety and abundance, as will be set forth in considerable detail throughout this issue of CHEMICAL & METALLURGICAL ENGINEERING. Certainly during the war the nation had reason to be thankful for the raw material and finished products which came out of this region.

By means of introduction to the details, which follow, we show opposite an industrial map of the region and give a few tables of condensed information.

The map shows the principal mineral products of the States and gives their relative rank among all similar deposits in the United States.

Table I, showing the mineral production of the Chicago District, was prepared by a local committee of the Chicago Section, A. I. M. E., for use in the souvenir guide book issued for the Chicago meeting of the Institute, Sept. 22-29. Tables II, III, and IV contain data compiled from the U. S. Census of Manufactures and give interesting comparisons on the manufacturing industries of the four States.

The census for 1919, now in preparation, will undoubtedly show a striking increase in all items in the four States.

TABLE II—RANK IN MANUFACTURING INDUSTRIES, 1904-14

	Wage Earners (Average No.)						Value of Products						Value Added by Manufacture					
	1914		1909		1904		1914		1909		1904		1914		1909		1904	
	Rank	Per Cent. Total	Rank	Per Cent. Total	Rank	Per Cent. Total	Rank	Per Cent. Total	Rank	Per Cent. Total	Rank	Per Cent. Total	Rank	Per Cent. Total	Rank	Per Cent. Total	Rank	Per Cent. Total
Illinois	5	7.2	4	7.0	4	6.9	3	9.3	3	9.3	3	9.5	3	9.2	3	8.9	3	9.1
Indiana	9	2.8	9	2.8	9	2.8	8	3.0	9	2.8	10	2.7	8	3.1	8	2.9	11	2.8
Michigan	7	3.9	7	3.5	8	3.2	7	4.5	7	3.3	8	2.9	7	5.0	7	3.7	7	3.2
Wisconsin	10	2.8	10	2.8	10	2.8	10	2.9	8	2.9	9	2.8	9	2.8	9	2.9	9	2.9

TABLE III—PER CENT INCREASE IN GROWTH OF MANUFACTURING INDUSTRIES, 1899-1914

	Wage Earners (Average Number)				Value of Products				Value Added by Manufacture			
	1904 to 1914	1909 to 1914	1904 to 1909	1899 to 1904	1904 to 1914	1909 to 1914	1904 to 1909	1899 to 1904	1904 to 1914	1909 to 1914	1904 to 1909	1899 to 1904
United States	28.7	6.4	21.0	16.0	63.9	17.3	39.7	29.7	37.0	15.8	35.5	30.3
Illinois	33.6	8.8	22.8	14.0	59.3	17.1	36.1	25.8	59.1	19.6	33.0	29.8
Indiana	28.1	5.6	21.3	10.9	85.5	26.2	47.0	16.9	77.0	25.4	41.1	22.2
Michigan	54.7	17.1	32.1	12.5	153.1	58.5	59.7	34.2	147.9	55.9	59.0	38.5
Wisconsin	28.3	6.4	20.6	10.1	69.1	17.8	43.6	25.8	51.1	13.9	32.7	30.4

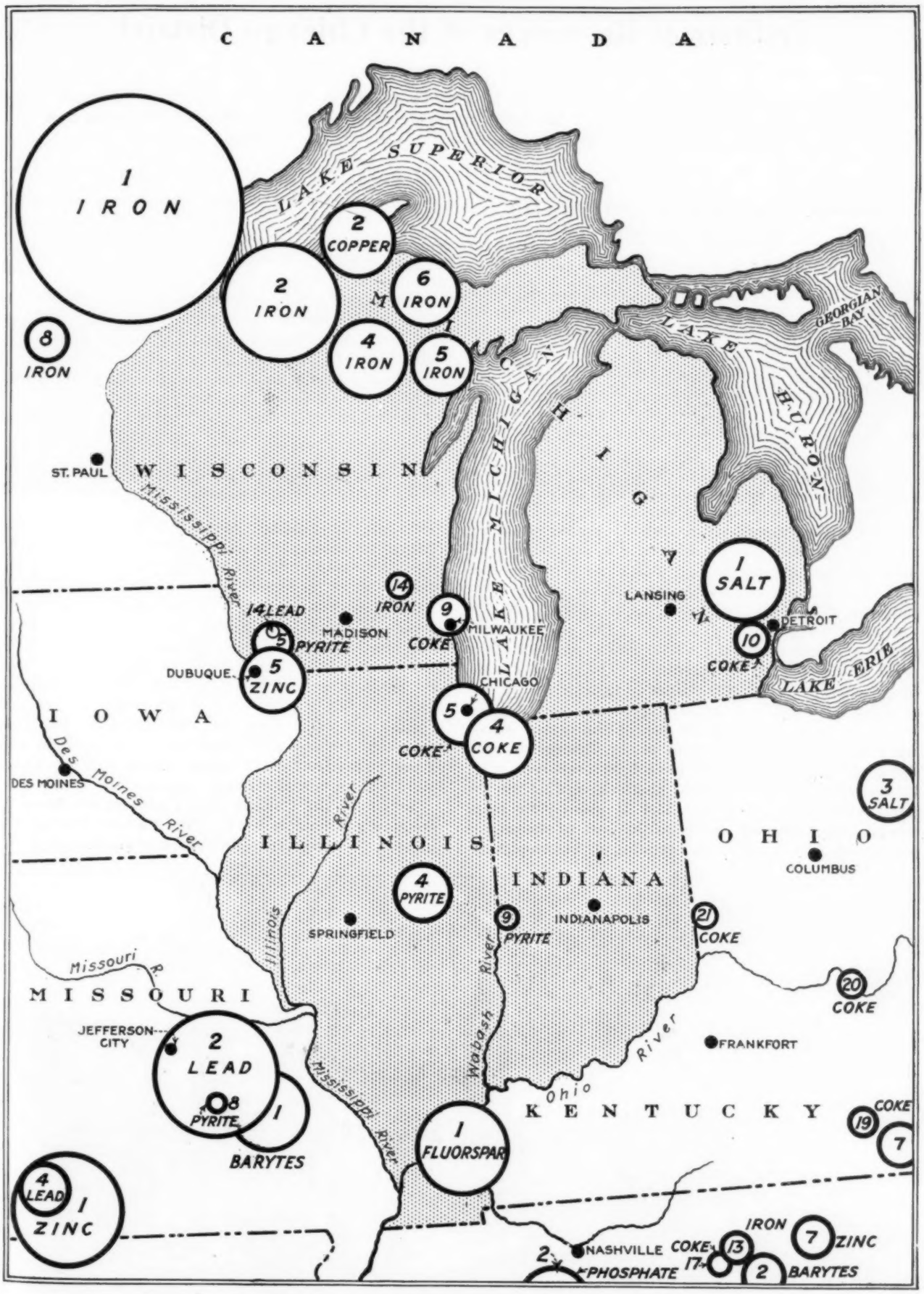
TABLE IV—VALUE OF PRODUCTS, 1899-1914

	1914	1909	1904	1899
United States	$24,246,434,724	$20,672,051,870	$14,793,902,563	$11,406,926,701
Illinois	2,247,322,819	1,919,276,594	1,410,342,129	1,120,868,308
Indiana	730,795,021	579,075,046	393,954,405	337,071,630
Michigan	1,086,162,432	685,109,169	429,120,060	319,691,856
Wisconsin	695,172,002	590,305,538	411,139,681	326,752,878

TABLE I—MINERAL PRODUCTION FOR 1917 OF THE CHICAGO SECTION DISTRICT (*a*)

Product	Illinois		Indiana		Michigan		Wisconsin		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Asphalt, short tons	110,756	$1,317,855							110,756	$1,317,855
Briquettes, fuel, short tons							*b c*	*b c*		
Bromine, pounds					735,654	$405,059			735,654	405,059
Calcium chloride, short tons					22,679	294,693			22,679	294,693
Cement, barrels	*d*4,378,233	*d*6,090,158	*d*8,148,678	*d*$11,084,930	4,313,771	6,122,887			16,840,682	23,297,975
Clay products		19,565,420		10,999,474		4,034,245		$1,122,121		35,721,260
Clay—raw, short tons	195,693	789,589	73,863	78,463	5,746	13,627	*b c*	*b c*		
Coal, short tons	86,199,387	162,281,822	26,539,329	52,940,106	1,374,805	4,426,314			114,113,521	219,648,242
Coke, short tons	2,289,833	*e*14,455,539	3,540,718	*e*21,831,302	*b c*	*b c*	*b c*	*b c*		
Copper, pounds					255,710,128	69,808,865			255,710,128	69,808,865
Ferroalloys, long tons	*b c*	*b c*								
Fluorspar, short tons	156,676	1,373,333							156,676	1,373,333
Gems and precious stones						95				95
Graphite, amorphous, short tons					*b*	*b*				
Grindstones						*b*				
Gypsum, short tons					375,803	1,568,655			375,803	1,568,655
Iron ore:										
Sold to furnaces, long tons					17,712,916	62,733,624	1,179,709	3,913,437	18,892,625	66,747,061
Sold for paint, long tons					1,445	*b*	982	*b*	2,427	
Iron, pig, long tons	3,458,126	*e*91,094,541	2,162,872	*b c*	611,446	*e*18,300,501	402,732	*e*11,032,274	6,635,176	
Lead, short tons	1,439	247,508					4,139	711,908	5,578	959,416
Lime, short tons	83,409	501,320	118,530	646,553	135,920	892,682	169,650	1,037,578	1,092,238	3,078,135
Magnesium, pounds					*b*	*b*				
Manganiferous ore, long tons					52,198	*b*			52,148	
Mineral paints (zinc and lead pigments), short tons	*b c*	*b c*					*b c*	*b c*		
Mineral waters, gallons sold	1,370,461	66,042	521,758	152,469	1,069,164	105,641	6,296,634	1,362,498	9,258,017	1,686,650
Natural gas		479,072		453,310		1,013				933,395
Natural-gas gasoline, gallons	4,934,009	866,033							4,934,009	866,033
Oilstones and scythestones				27,693						27,693
Peat, short tons	*b*	*b*	*b*	*b*						
Petroleum, barrels	15,776,860	31,358,069	759,432	1,470,548	*b*	*b*				
Potash, short tons	*b*	*b*			381	299,395	277	259,928		
Pyrite, long tons	24,596	89,998	*b*	*b*			*b*	*b*		
Salt, short tons					2,250,939	6,877,202			2,250,939	6,877,202
Sand and gravel, short tons	9,120,698	3,658,799	5,906,196	1,591,158	3,814,445	1,641,748	3,609,869	1,080,860	22,451,208	7,972,565
Sand and sandstone (finely ground), short tons	386,866	630,256							386,866	630,256
Sand-lime brick				60,201		370,723		*b*		
Scythestones						*b*				
Silica (quartz), short tons					*b*	*b*	*b*	*b*		
Silver, fine ounces (Troy)	7,166	5,921			688,551	567,366			695,737	573,287
Stone		3,322,041		4,449,809		3,423,825		2,787,023		13,982,698
Sulphuric acid, short tons(*e*)		3,902,831	*b*	*b*			*b*	*b*		
Tripoli		31,338								31,338
Zinc, short tons	4,267	870,468					59,742	12,187,368	64,009	13,057,836
Miscellaneous (*f*)		6,343,662		51,582,551		5,791,496		9,017,291		72,735,000
Total values, eliminating duplications		$236,934,22		$85,079,370		$163,997,853		$24,976,780		$510,988,232

a. Published by permission of the Director of the United States Geological Survey subject to final revision.
b. Value included under "Miscellaneous."
c. Value not included in total value.
d. Exclusive of natural cement, value for which is included under "Miscellaneous."
e. From zinc smelting.
f. Natural cement, ferroalloys, zinc and lead pigments, peat, potash, pig iron, pyrite, sulphuric acid from zinc smelting, coke, amorphous graphite, grindstones, iron ore sold for paint, magnesium, manganiferous ore, petroleum, scythestones, silica (quartz), fuel briquettes, raw clay, and sand-lime brick.



RESOURCE MAP OF THE NORTH CENTRAL STATES

The figures in the circles show the relative rank among all similar deposits in the United States. Adapted from a complete map of the United States prepared by the Nashville Section, Engineering Association of the South.

Industrial Resources of the Chicago District

Metallurgically, Chicago Ranks Second Only to Pittsburgh as a Producing Center, While in Non-Ferrous Operations Refining and Alloying Are Extensively Represented — Oil Refining and Packing House Products Represent the Most Extensive Chemical Interests

Non-Ferrous Metallurgy in the Chicago District

By H. B. Pulsifer

NOT infrequently we have asserted and defended the statement that Chicago is the very greatest metallurgical center on the globe. Pittsburgh with its pre-eminence in iron and steel has to be considered, but with Pittsburgh the argument largely ends with the great iron and steel plants; Chicago comes second in iron and steel, but its real claim to greatness is in the abundance and variety of the non-ferrous metallurgical plants.

In the Chicago district one finds 35 great plants of prime importance, as well as over 200 foundries. In 1917 the author, with his students at Armour Institute of Technology, undertook a sort of census of these foundries in the Chicago district. It was desired to check up the current lists of plants, note the sort of work and equipment at each, the number of men employed as well as the presence of technical men, and the attitude toward using graduates. The results were amazing: plants employing a thousand or more men had never before come to our attention. The range of work surprised one: every stage from antipathy to full use of technical talent had several representatives.

In order to present a clear idea of the varied metals and processes one will discover in the Chicago district, the accompanying two lists have been prepared. List I arranges the more notable plants according to the metal handled or produced. List II groups the more conspicuous plants according to the sort of operations performed, such as smelting, refining or electroplating

It is frankly admitted that the lists are incomplete; in fact, the author has never started out on a metallurgical exploring trip about the great inland metropolis without abundant discoveries as to plants, metals and processes.

Surprisingly large and diversified amounts of ores and concentrates come to Chicago for treatment. Instances of this sort have been Butte zinc concentrates and Wisconsin zinc concentrates for roasting, Boss platinum ores from Nevada, lead concentrates from Wisconsin, antimony ores from South America, gold bullions from cyanide plants, lead bullions from Mexico, sweepings from the United States and Canadian mints.

Chicago Pre-eminent in Secondary Metal Recovery

It is in the secondary metal recovery, however, that Chicago probably ranks as pre-eminent. This business amounts to many millions of dollars a year. Scrap and junk metal is reclaimed in the usual furnaces and by similar processes as virgin metal, again going on the market indistinguishable from metals and alloys direct from ores. The abundance of almost every sort of scrap metal makes it profitable to make brass, bronze, solders, babbitts and various other alloys from reclaimed stock, possibly adding some fresh stock to bring to specification. One dare not say that gold bars from sweepings are less pure than bars from cyanide mills or that brass from scrap copper trolley wire is inferior to brass from new electrolytic ingots.

Certain of the Chicago plants are always doing interesting and notable work. The Western Electric Co., Crane & Co., the Great Western Co., Goldsmith & Co.,

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SKYLINE OF CHICAGO—GRANT PARK IN THE FOREGROUND

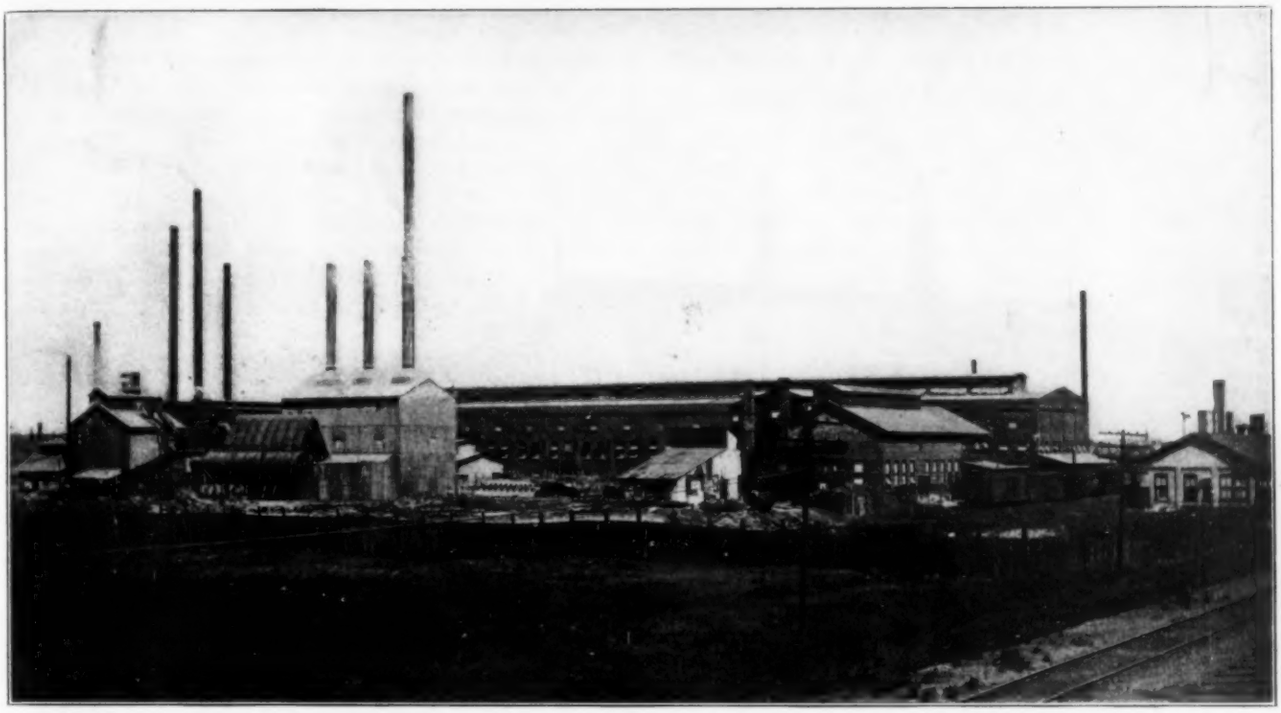


FIG. 1. THE UNITED STATES METALS REFINING PLANT AT EAST CHICAGO

the International Lead Co., the United States Co., the International Harvester Co. and the National Lead Co. may each have a dozen furnaces on the most varied work. Oxide copper furnaces are at work just as they used to be in Arizona during the '80s, and the slags are high in copper, too. Small copper reverberatories are getting out tough pitch copper just as the big furnaces do at Great Falls and Perth Amboy. Lead blast-furnaces are making bullion and matte just as they do in the West; one of the neatest bag houses is right in the heart of the city, and another fine example is at East Chicago.

It can hardly be held that much of the plant work is less metallurgical because it is joined up with metal preparation and manufacturing processes. Most of the Chicago plants add to the smelting, refining, graining and shaping of the metals also the final factory operations which put the stock on the market for ultimate consumption. Thus the Goldsmith plant is fundamentally a precious-metal plant, but the company is also widely known as furnishing dental specialties. The National Lead Co., with all its furnaces, alloying and extrusion work, is better known as supplying pigments

LIST I—METALS PRODUCED, REFINED AND PREPARED IN THE VICINITY OF CHICAGO

Iridium	Goldsmith Bros. S. & R. Co.
Palladium	Goldsmith Bros. S. & R. Co. Thomas J. Dee & Co.
Platinum	Goldsmith Bros. S. & R. Co. Thomas J. Dee & Co.
Gold	Goldsmith Bros. S. & R. Co. Thomas J. Dee & Co. Alexander Cassriel Co.
Silver	Goldsmith Bros. S. & R. Co. Thomas J. Dee & Co. Alexander Cassriel Co.
Tungsten	The Pfanstiehl Co.
Tin	Metal & Thermit Corporation
Bismuth	United States Metals Refining Co.
Aluminum	United States Reduction Co. Castings made in score of foundries.
Copper	Great Western S. & R. Co. Chicago Bearing Metal Co. Goldsmith Bros S. & R. Co.
Lead	United States Metals Refining Co. International Lead Refining Co. Goldsmith Bros. S. & R. Co. National Lead Co. Carter White Lead Co. Great Western S. & R. Co. Raymond Lead Co.
Brass and bronze	Made, cast and worked in scores of foundries and plants.
Solders	Great Western S. & R. Co. National Lead Co.
Babbitts	Great Western S. & R. Co. National Lead Co. Fort Dearborn S. & R. Co.
Hard lead	International Lead Refining Co. United States Metals Refining Co. Great Western S. & R. Co. National Lead Co.

LIST II—METALLURGICAL OPERATIONS ACTIVELY PROSECUTED IN THE VICINITY OF CHICAGO

Concentrating	Jigs, tables and fine grinding mills are found in connection with several foundries.
Leaching	Few instances in strictly metallurgical works, common in the chemical plants.
Roasting	Grasselli Chemical Co. has two standard Hegeler zinc roasting furnaces in constant use. Goldsmith Bros. S. & R. Co. has a Dwight-Lloyd roast-sintering machine.
Smelting	Chicago Bearing Metal Co. International Lead Refining Co. United States Metals Refining Co. Goldsmith Bros. S. & R. Co. National Lead Co. Great Western S. & R. Co.
Refining	International Lead Refining Co. United States Metals Refining Co. Goldsmith Bros. S. & R. Co. Great Western S. & R. Co. Thomas J. Dee & Co.
Dissolving	Grasselli Chemical Co. Goldsmith Bros. S. & R. Co.
Bag Houses	International Lead Refining Co. Goldsmith Bros. S. & R. Co. United States Metals Refining Co.
Cupelling	International Lead Refining Co. United States Metals Refining Co. Goldsmith Bros. S. & R. Co. Thomas J. Dee & Co.
Granulating	Carter White Lead Co. Goldsmith Bros. S & R. Co.
Briquetting	Metal Block & Ingot Co.

Rolling, Drawing, Spinning, Extruding, Wire Drawing, Pressing and Stamping of most common metals practiced in scores of plants.

Casting of iron, steel, brass, bronze and aluminum carried out in over 200 foundries.

Electroplating carried out in more than a dozen large plants.

Metallographic Laboratories	Illinois Steel Co. Robert W. Hunt & Co. Armour Institute of Technology.
Analytical and Consulting Laboratories	Robert W. Hunt & Co. Kawin & Co. Columbus Laboratories. Armour Institute of Technology. Indiana Laboratories.
School	Armour Institute of Technology.

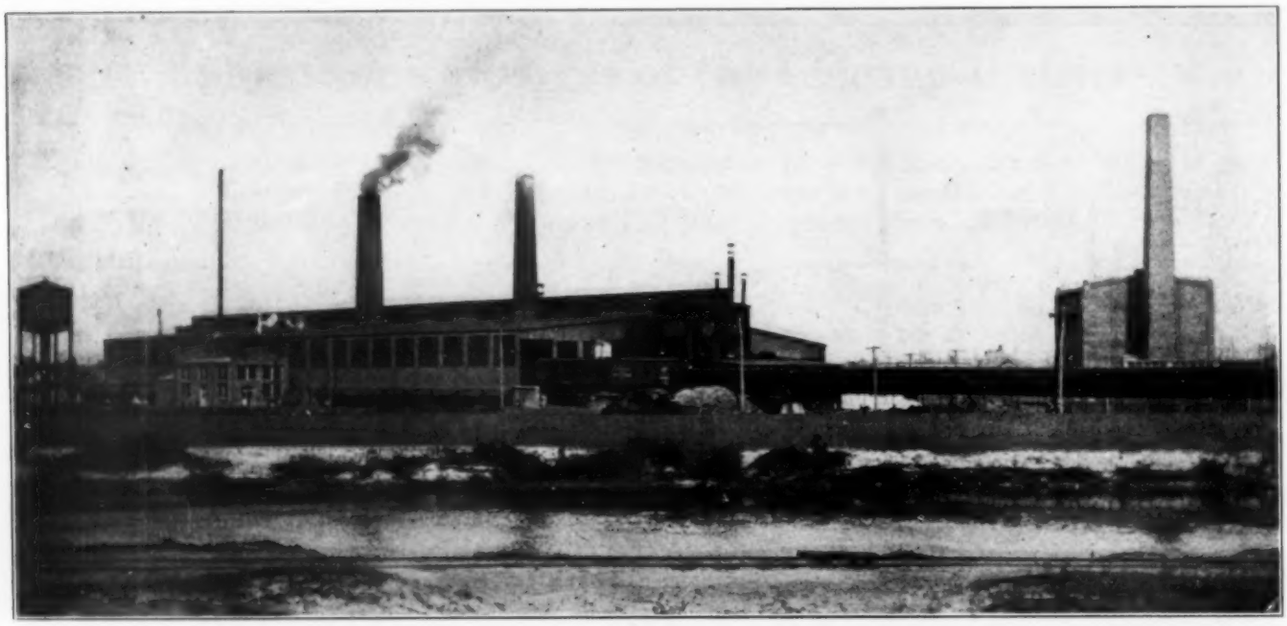


FIG. 2. THE INTERNATIONAL LEAD REFINING CO.'S PLANT AT EAST CHICAGO

and paint. The Grasselli Chemical Co., with its roasters and metal dissolving facilities, is known rather as supplying acids and salts. A certain large manufacturing jeweler employing 50 or 60 men in a corner of one floor of a huge office building is apparently only busy at making rings and pins and setting precious stones, but really he is even more fundamentally interested in alloying, deoxidizing, hardening, shaping, electroplating and reclaiming scrap and sweepings. The International Harvester Co. makes and sells farming implements, but we would consider it a rather large metallurgical plant which operates 4 cupolas, 8 air furnaces and numerous brass furnaces.

The United States Metals Refining Co.

The United States Metals Refining Co. has possibly the most important and interesting plant near Chicago, excluding the steel plants. This is an electrolytic lead refinery; base bullion from the West is the chief raw material, electrolytic lead and pure bismuth are the two chief finished products. The precious metals in the form of doré slabs are sent to Chrome, N. J., for final separation and purification. Besides the immense tank house and remarkable electrolytic work, the plant produces hydrofluoric acid and hard lead alloys. In the recent death of William Thum, long superintendent of the plant, not only the community loses a strong and able character but the metallurgical world a penetrating investigator and constructive scientist. The plant has accomplished much in the refining of lead, the treatment of the electrolytic slime and the winning of the very purest bismuth. Our view of the plant in Fig. 1 shows the immense tank house in the rear with the (from the right) office, fluosilicate building, bag house and blast-furnace building across the foreground.

The International Lead Refining Co.

The International Lead Refining plant was built at East Chicago under the direction of George Hulst, a very capable manager in the lead refining business. This is the most modern of the world's lead refineries using the Parkes process. It is the lead refining department of the Anaconda Copper Mining Co. At the right in Fig. 2 one sees the striking bag house, while the main furnace building is at the left. The plant has never really been pushed to capacity and is designed for expansion to much larger size. Besides operating it at remarkably efficient cost, Hulst has done much interesting work in smelting antimony ores for the hard-lead trade.

The Goldsmith plant is possibly the most versatile in the whole district. Precious metal values are recovered from concentrates, ores, residues and sweepings by sintering, smelting and the Parkes process of desil-

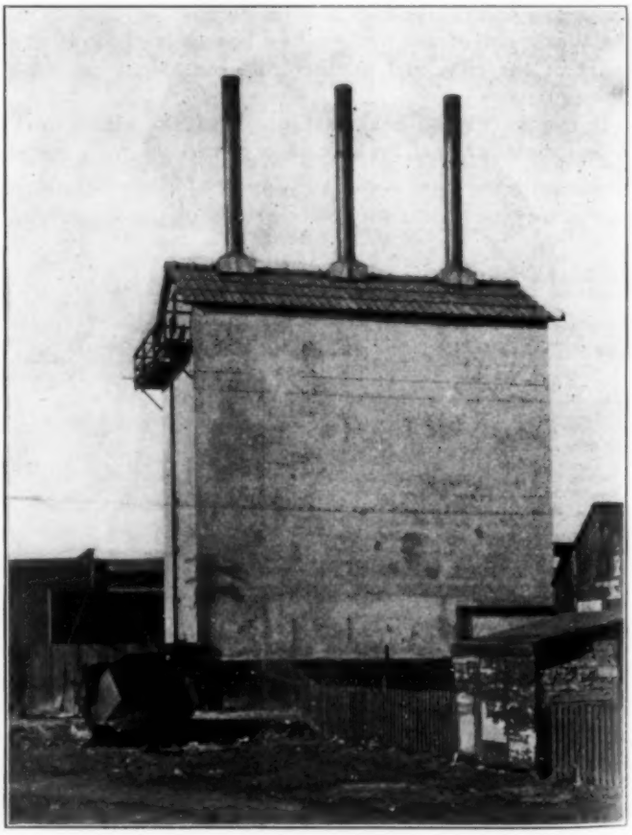


FIG. 3. THE GOLDSMITH BAG HOUSE, 58TH AND THROOP

verization. Precious metal parting is performed by acids and pure iridium, palladium, platinum, silver and gold are produced. Iridium is marketed as powder or in hard platinum, but the other metals are melted and sent out in bars, rolled plate, granulated or as salts. A unique copper-dissolving tank used in the manufacture of blue stone, a model bag house (Fig. 3) and improved chemical laboratory were features designed by the author. The plant manufactures a splendid line of dental cements, largely the product of an Armour Institute graduate. Osmic acid, silver chloride and silver nitrate, gold chloride and blue stone are further plant products. Fig. 4 is a view in the melting room; 18-in. dishes for parting gold bullions are on the table and a wheelbarrow of silver is at the right. The silver is melted in the crucible furnace at the right and the parting done in the oven behind the two men. The diagram of the plant as given in Fig. 5 indicates the spread of the plant; it has recently been largely rebuilt.

Great Western Smelting & Refining Co.

The Great Western Smelting & Refining Co. plant is equipped with machines for grinding, washing and briquetting metallic residues. There is one cupola, or blast-furnace, and reverberatories for matte, solder, lead, brass, copper and copper refining. There are eight pit furnaces for crucibles, a sweating furnace and three large melting kettles. Precious metal residues are not handled, but otherwise the plant reclaims most of the non-ferrous wastes of civilization and turns out a long list of metals and alloys. An adequate laboratory enables work of precision to be done.

LOCATION OF THE MORE PROMINENT METALLURGICAL PLANTS IN THE CHICAGO DISTRICT

1—International Harvester Co. 2—National Malleable Castings Co. (Laramie Ave. plant). 3—National Malleable Castings Co. (Rockwell Street plant). 4—Link-Belt Co. 5—Great Western S. & R. Co. 6—Chicago Bearing Metal Co. 7—Chicago Steel Foundry Co. 8—Crane Co. 9—Metal Block & Ingot Co. 10—Thomas J. Dee & Co. 11—Illinois Malleable Iron Co. 12—National Malleable Castings Co. (Melrose Park plant). 13—The Pfanstiehl Co. 14—Aurora Metals Co. 15—Illinois Steel Co. (Joliet plant). 16—Interstate Iron & Steel Co. 17—Illinois Steel Co. (South works). 18—Burnside Steel Co. 19—Sheet & Tube Co. of America (Iroquois plant). 20—Pollak Steel Co. 21—Wisconsin Steel Co. 22—By-Products Coke Corp. (Federal furnaces). 23—National Lead Co. 24—Chicago Malleable Castings Co. 25—General Chemical Co. 26—Inland Steel Co. 27—American Steel Foundries Co. 28—Sheet & Tube Co. of America (Mark plant). 29—Sheet & Tube Co. of America (East Chicago plant). 30—United States Metals Refining Co. 31—Hammond Malleable Castings Co. 32—Republic Iron & Steel Co. 33—Metal & Thermit Corp. (Goldschmidt plant). 34—Grasselli Chemical Co. 35—International Lead Refining Co. 36—Indiana Steel Co. (Gary plant). 37—Goldsmith Bros. S. & R. Co. 38—Universal Draft Gear Co. 39—American Manganese Steel Co. 40—Columbia Tool Steel Co. 41—Railway Steel Spring Co. 42—Calumet Steel Co. 43—Union Drawn Steel Co. 44—Chicago Metal Treating Co.

FIG. 4. VIEW IN THE MELTING ROOM AT GOLDSMITH'S

The Thomas J. Dee Plant

The Thomas J. Dee plant is on the North Side of Chicago, a small heavily barred strong-box for precious metal work. Furnaces are installed for melting and refining the precious metals, while the acid process is used for parting. Besides turning out bars and slabs, the plant features drawing precious metals into wire. After the short, thick rods are cast they are swaged down and then drawn through dies to specified size. Gold, silver, platinum and their alloys are thus treated for the market.

It is obvious that Chicago is a great lead refining center and a heavy producer of the precious metals, either pure or alloyed. It is also a conspicuous center for the antimony-lead alloys, bismuth, the copper and tin bearing metals, and solders. A large portion of this business comes through the smelting, refining and alloying of junk materials.

The most conspicuous voids in the general metallurgical field result from the absence of much virgin ore reduction, leaching operations, electrolytic copper refining and zinc smelting. For the electrolytic copper refining one must go far, either West or East, but for the zinc smelting a short trip to LaSalle and DePue puts one among the greatest plants.

School of Mines,
Butte, Montana.

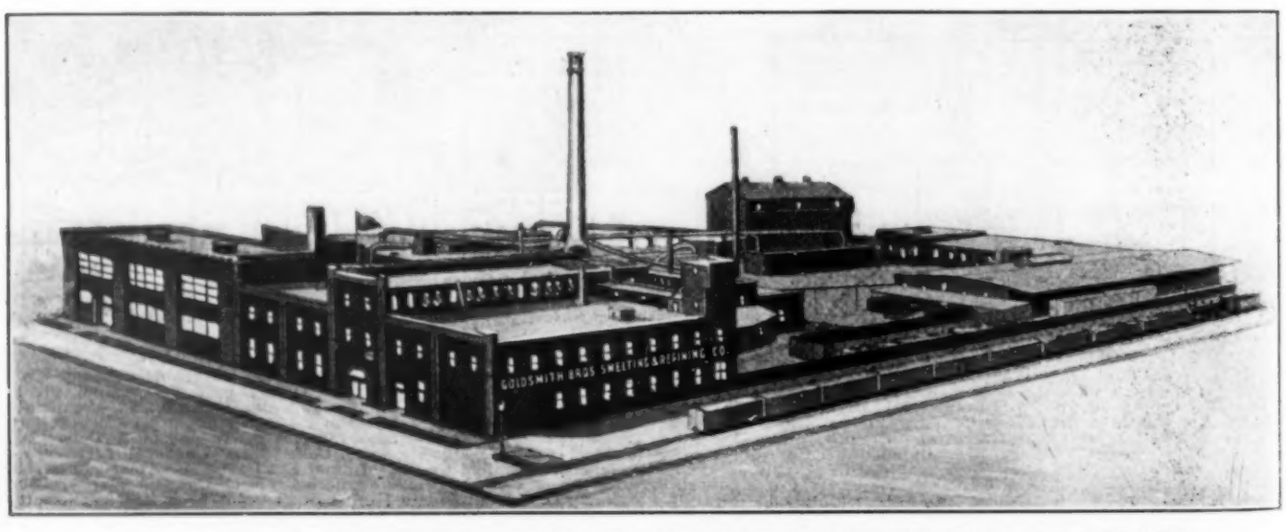


FIG. 5. DIAGRAM OF THE GOLDSMITH PLANT: MORE RECENTLY MUCH REBUILT AND IMPROVED

Chemical Industries of Illinois and the Chicago District

By Procter Thomson

THE fortunate geographic location of Chicago has led to the development of a wonderful system of transportation facilities. This consists not only of the numerous railways which radiate from Chicago in every direction, but includes the various belt lines and clearing yards which facilitate the movement of goods from one railroad to another. The coal fields of Illinois and Indiana insure a plentiful and sure supply of fuel at low cost. When Eastern cities are tied up with freight congestion, Chicago has found it possible to obtain raw materials and fuel and to ship finished goods. The appreciation of these factors is leading to the development of Chicago as an industrial center. This development has extended beyond the border of Illinois and over into Indiana. As these northern Indiana industries are in the Chicago district, they will be considered here instead of with Indiana industries. Chemical industry has taken part in this growth in a greater degree than is generally known.

The chemical industry of Illinois other than the Chicago district is considerable. It participates in the transportation advantages of Chicago, but is generally the result of nearby sources of raw material. This is particularly the case of the zinc industry with the associated acid plants.

By-Product Coke Plants

Illinois has unlimited supplies of limestone and fluorspar, which, in addition to the factors already named, contribute to the growth of the iron and steel industry, which has reached great proportions and is still growing.

The Interstate Iron & Steel Co. has four open-hearth furnaces at South Chicago.

Closely associated with iron and steel is the by-product coke industry. This has reached tremendous proportions. The United States Steel Corporation has 700 Koppers ovens at Gary and 280 Koppers ovens at Joliet. The total coking capacity of these ovens is 12,000 tons of coal per day.

The By-Products Coke Corporation operates 280 Semet Solvay ovens at South Chicago and has 120 more nearly ready to operate at Indiana Harbor. The combined capacity of these 400 ovens will be 45,000 tons of coke per month.

Miscellaneous Metallurgical Industries

Most of the metallurgical activity in the Chicago district other than iron and steel is in the refining of trade wastes. There are notable exceptions to this, however. One of these is the Fansteel Products Co. This company at North Chicago is producing metallic tungsten, molybdenum, and cerium of great purity. The tungsten is produced from wolframite, and the molybdenum from ammonium molybdate or molybdic oxide. The processes are practically the same for both metals. The raw material is fused with sodium carbonate, the soluble salts of the metals leached out, and by alternate precipitation with acid and solution in alkali, with the accompanying filtering and washing, oxides of a high degree of purity are produced. After ignition the oxides are reduced by hydrogen. The metallic powder is pressed into bars and sintered electrically. These bars are then swedged into the desired shape. The tungsten is cut into discs and mounted on the proper supports for electrical-contact apparatus. The molybdenum is used in the manufacture of spiders for tungsten filaments. Metallic cerium is produced from materials obtained from the Lindsay Light Co. A pure cerium chloride is made which is fused and electrolyzed and metallic cerium recovered. This is used in pyrophoric alloys.

Paint Pigment

The manufacture of paint pigments is carried on at a number of plants in Illinois. Lithopone is manufactured by Sherwin-Williams at Pullman, the Midland Chemical Co. at Argo and the Consolidated Chemical Products Co. at Alton. The Sherwin-Williams Co. manufactures corroded white lead and dry colors, including prussian blue, chrome yellow and para toners.

The National Lead Co. has a large plant producing corroded white lead by the old Dutch process, red lead and litharge. Here also, babbitts, solder and metals for tempering baths, etc., are produced.

The Carter White Lead Co. produces white lead in South Chicago.

Heavy and Inorganic Chemical Manufacture

The field of heavy and inorganic chemical manufacture is well taken care of by Illinois and the Chicago district. The General Chemical Co., with factories at South Chicago, Chicago Heights and East St. Louis, manufactures a general line of heavy chemicals, including mineral acids, sodium sulphide, zinc chloride, silicate of soda, aluminum sulphate, soda alum and contact sulphuric acid.

The Grasselli Chemical Co. manufactures heavy chemicals at East Chicago.

The Central Chemical Co. at West Hammond, Ill., produces brimstone sulphuric acid, hydrochloride acid and nitric acid.

One of the most interesting developments in Chicago is the Lindsay Light Co., which originally was a producer of incandescent mantles for gas lights, but market conditions in 1914 led it to become a producer of the basic materials used in the mantle industry. The raw material used is monazite sand from India. From this the company is producing thorium nitrate, cerium salts and titantium potassium oxalate. It is almost alone in this field. Beryllium and antimony salts are also being produced. Since the signing of the armistice it has been preparing for the production of dyestuffs and will soon be in the market with phthalic anhydride, phenolphthalein, methylene blue, fuchsine and other products of like nature.

Most people think of borax as being produced in the region where raw materials are found. The Thorkildsen-Mather Co., however, finds conditions in Chicago so favorable to chemical industry that it has located its factory here. It produces borax in the stockyards district from California colemanite.

The production of radium compounds is also being carried on in Chicago—the Carnotite Reduction Co. is producing radium bromide and vanadium compounds from Colorado carnotite.

The Superior Chemical Co. at Joliet is making filter alum, cream of tartar substitute and soda alum, using Arkansas bauxite. Located near by is the Superior Phosphate Co., manufacturer of calcium phosphates.

Stiesen-Reuter & Hancock are producing metallic

salts and soaps of lead, manganese, cobalt, iron and zinc, also aluminum salts and calcium and magnesium stearate and oleate.

The Chicago Copper & Chemical Co. produces barium salts, glaubers salts and sodium sulphide.

The Victor Chemical Co. has a large plant at Chicago Heights. Among other products, the company manufactures at the present time monocalcic and dicalcic phosphate, monosodium and disodium phosphate, monoammonium and di-ammonium phosphate, phosphoric acid, epsom salts, sulphuric acid and oxalic acid. Oxalic acid is one of the latest additions to its line and is made by the synthetic process, which is claimed to produce an acid of superior strength and purity.

The Dearborn Chemical Co. has found Chicago a most convenient place to build up an extensive business in boiler compounds and water treatment. It is also manufacturing an interesting rust inhibitor, which consists of a petrolatum-like product with the rust-inhibiting compounds emulsified therein.

The Illinois Match Co. has a factory at Joliet.

The Illinois Glass Co. has a large plant at Alton and a small one at Chicago Heights, Ill., for the production of bottles. The glass at the Alton plant is produced by the continuous process. New equipment has been developed for this plant for the machine blowing of very large bottles.

Packing-House Chemical Industries

The location of packing-house interests in Chicago has led to the growth of extensive chemical manufacturing along the lines of soap, glue, glycerine, fertilizers, etc. All of the packers are working with cottonseed, soya bean and other vegetable oils in addition to the fats. It is interesting to note that not all of the packers do the same things. They appear to differ in their opinions as to the advisability of certain chemical manufactures.

Armour & Co. manufacture anhydrous ammonia, soap, glue, glycerine, fatty acids, animal fertilizers (tankage, bone meal), acid phosphate and rock phosphate. They refine and hydrogenate oils for lard substitutes, etc.

Morris & Co. make anhydrous ammonia, glycerine, fatty acids and refined and hydrogenated oils.

Swift & Co. manufacture soap, glycerine, fatty acids, glue, acid phosphate and mixed fertilizers, refined and hydrogenated oils, and oxygen.

The chemical activities of Wilson & Co. are confined to refining and hydrogenating oils, manufacturing fertilizers and glue.

Abbatoir pharmaceuticals are manufactured by Armour & Co. and by the Hollister-Wilson Co., which has just completed a new plant. Both firms manufacture digestive ferments, organic extracts and organotherapeuticals.

GREAT WESTERN SMELTING & REFINING CO. PLANT

There are a number of soap manufacturers in Chicago who operate independently of oil or fat manufacture. Typical of these are Fitzpatrick Bros., James S. Kirk & Co. and the Allen B. Wrisley Co.

Similarly situated are glue and fertilizer manufacturers who purchase their raw materials from various sources. The United Chemical & Organic Products Co. at West Hammond, Ill., manufactures gelatine, glue, fertilizers, etc.

Chicago has a great number of tanners. Most of them are conducting operations by rule-of-thumb methods, so they cannot really be classed as chemical industries.

Not to be classed as a packing-house activity but closely associated in character is cottonseed oil refining. The American Cotton Oil Co. and the N. K.

Fairbank Co. have a large plant in Chicago for the refining of oils. Their principal source is the cottonseed oil from their own mills in the South. Here they refine and hydrogenate cottonseed and other vegetable oils and distill fatty acids, producing soap products, glycerine, lard compounds, cooking oil and salad oil. It is especially interesting to note that the American Cotton Oil Co. has established a research department which is on an equal basis with the production department and sales department. Research for all of the plants is carried on here.

Miscellaneous Organic Industries

The Corn Products Refining Co. has a large factory at Argo. Here it produces starches, dextrines, corn syrup, corn sugar and corn oil for industrial purposes, as well as salad and cooking oil.

The Redmanol Chemical Co. produces its anhydrous phenol resin. Using this as a base it molds a great variety of products ranging from cigar holders to electrical insulating materials. It has recently perfected a cold molding compound.

The Abbott Laboratories was originally a producer of alkaloids for medical use. In addition to the extraction and purification of alkaloids it now manufactures a number of synthetic organic pharmaceuticals. These include the Dakin antiseptics—chlorazene, dichloramine T, chlorcosane (a solvent for dichloramine T) and halazone. It is also producing procaine (novocaine) and dimethyl barbituric acid (veronal).

Burke & James sensitize photographic paper and films.

The Carus Chemical Co. in La Salle, Ill., manufactures saccharine, chloramine T and potassium permanganate.

An interesting plant, which has duplicates at other points in the United States, is the carbon dioxide plant of the Liquid Carbonic Co. Here power is obtained as a by-product. Coke is burned under boilers, the flue gas is scrubbed with water and absorbed in alkaline solution in large absorbing towers. The solution is then heated, the CO_2 driven off, collected, and compressed to 1000 lb. per sq.in. in cylinders. The steam produced by burning the coke runs the compressor and leaves a surplus for other purposes.

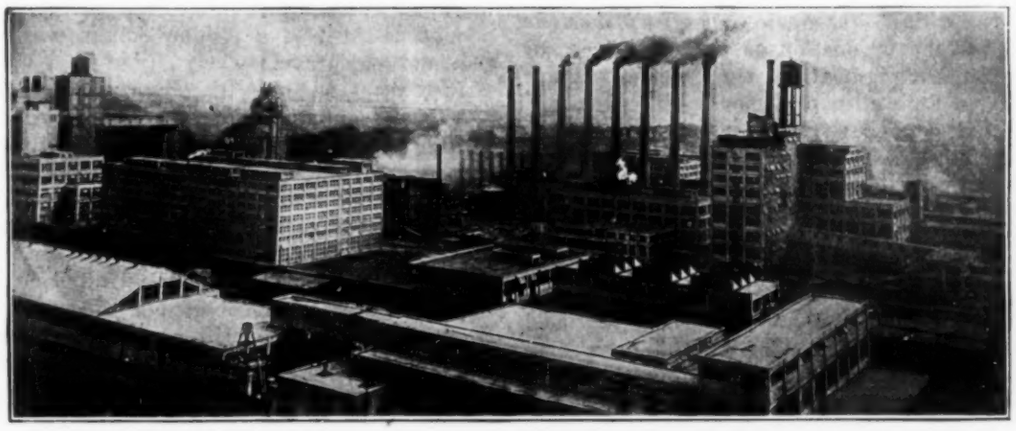
The Peoples Gas Light & Coke Co. has installed four light oil reclaiming plants to save the benzene, toluene, etc., produced in its water gas plants. The recovered oil is refined at its central refinery and various grades of benzol, toluol, solvent naphtha, etc., produced. Ultimately the company plans to have its own by-product coke ovens.

The Barrett Co. has a plant in Chicago for the refinery of coke-oven tar. Here it separates the pitch, light oil and heavy oil. Further refining of the light oil into benzol, etc., is taken care of at Eastern plants of the company.

Chicago has a number of rubber manufacturers. The Inland and the Century Rubber companies produce tires. The United States Rubber Co. (the Mechanical Rubber Co.) has a large plant producing belting, hose and molded soft rubber goods. The Dryden Rubber Co. produces molded goods and auto tubes and is contemplating engaging in the manufacture of tires.

The Essenkay Products Co. produces rubber substitutes—vulcanized oils—which are used in the rubber trade as well as for erasers, tire fillers, bath sponges, etc.

The field of dyestuffs is covered by three plants in Illinois in addition to the Lindsay Light Co., already mentioned. The Sherwin-Williams plant at Pullman is producing a great many of the dyes and intermediates formerly imported. Among the products are beta naphthol, mono-acid, Schaffer salt, R salt, G salt, Tobias acid, trisulphonic acid, acet-toluide, anthranilic acid, ponceau 5 R, lake orange B, lake red D, lake red C, scarlet 3 R, scarlet 2 RR, naphthol yellow S, pigment scarlet 3 B, orange GG, alizarine yellow GB, alizarine yellow G, alizarine yellow RW, alizarine brown 3 R, alizarine brown B, crocein scarlet, orange Y, brilliant orange 4 GR, scarlet 2 RG, fast red TEX, fast red A, fast red 3 BX, fast red 6 BX, lake red P pulp, litho fast orange O, graphic red R pulp, graphic red Y pulp, brilliant crimson No. 10, chrome black B, chrome black JB, acid claret B, fast acid milling black, methyl violet, paraphenylenediamine, ursol DB, ursol P, leather brown, fuchsine X, XX, XXX, XXXX, fuchsine crystals, alkali blue, spirit blue, soluble blue. It has also an acetic acid plant.



PLANT OF THE CORN PRODUCTS REFINING CO.

The Monroe Color & Chemical Co. at Quincy was forced into dyestuff manufacture to keep up a flourishing package dye business which had been built up on imported material. It is now making H acid, benzidine, dinitrobenzene, metaphenylene, diamine, benzo blue BB, navy blue, diamine green, brigot green, benzo orange, benzo purpurine and Monroe direct black, and

is able to supply its own needs and have a surplus for sale.

Dicks, David & Heller, at Chicago Heights, have been manufacturing since July, 1917, starting with fuchsine. They are now making fuchsine crystals, alkali blue, soluble blue, water blue, phosphine, malachite green and metinol yellow and are having success in foreign markets formerly filled with German products.

The Special Chemicals Co., Highland Park, was organized to produce certain unusual chemicals practically unobtainable in this country since the war. Among its products are a number of the rare bacteriological sugars and their alcohols such as inulin, glactose, levulose, xylose, dulcite and mannite. The company maintains a research department and expects constantly to add to the list of sugars now available. It also manufactures such chemicals as dimethylglyoxime, nitroso-beta-naphthol, cupferron, potassium cyanate and chemically pure uric acid. The raw material for this last named product was formerly sent from this country to Germany, manufactured there into pure uric acid, and subsequently resold in this country. It is just this condition of affairs that Special Chemicals Co. hopes to help correct.

Several firms whose main line is far from chemical have gone into chemical manufacture to fill special needs.

Sears, Roebuck & Co. have a paper mill with a capacity of 17 tons per day. Its waste paper furnishes the raw material for the production of paper suitable for wall paper. Mineral pigments are made, and organic lakes precipitated for wall paper colors.

The Western Electric Co., while not ordinarily considered in speaking of chemical manufacture, is conducting chemical operations of considerable magnitude and interest. This company has an extensive hard rubber department manufacturing rod, sheet, telephone receivers, etc.; a metal finishing division doing plating, sherardizing and Bower-Barff work; and a cable sheathing department producing about 40,000 tons of lead alloys per year. The production of ceramic insulation has been started and is likely to develop to considerable proportions. The most interesting development, however, is the refining of iron electrolytically. The plant for this purpose produces about seven tons per week. So far as known this is the only commercial plant in operation in the United States.

Refineries

Two refineries are located in the Chicago-Gary district, that of the Standard Oil Co. at Whiting and that of the Sinclair Refining Co. at East Chicago. The Whiting plant has a capacity of 35,000 bbl. of crude petroleum per day and the East Chicago plant of 6500 bbl. The crude petroleum is pumped direct from the Mid-continent field through two pipe lines that enter Illinois just north of Keokuk, Ia., and lead directly to these two refineries. The usual great variety of refinery products originate here, and the plants are interesting rather on account of the scale of their operation than because of unusual methods and equipment.

Clay Products

In the 24 ceramic plants in Cook County, Illinois, and the one in Lake County, Indiana—the two counties in which the Chicago-Gary district is included—well over $5,000,000 worth of brick and tile products and about $200,000 worth of pottery products, making in all a total of more than $5,500,000 for the ceramic industries, are manufactured. Common brick makes up somewhat more than half of the total value and architectural terra cotta, fireproofing, drain tile, floor tile, red earthen ware and sanitary ware are among the many other varieties of clay products manufactured in this district.

The North Western Terra Cotta Co. has the only terra cotta plant in the district. Ordinary clays from Indiana and crucible clays from all over the United States go into their 25,000 tons of terra cotta and the 100,000 high-grade smelting crucibles produced annually.

The Harbison-Walker Refractories Co. of East Chicago is equipped to make 100,000 silica brick daily. Its raw silica is quartzite from the Devils Lake (Baraboo) district of Wisconsin.

The abundance of ordinary raw clays in the surrounding district, the ease with which fuel and special raw materials are obtainable, and the large and growing market afforded by the industries and large population make of Chicago and its vicinity an admirable location for ceramic industries.

Stone, Sand and Gravel

About $2,000,000 represented the value of stone produced in Chicago and immediate vicinity for 1917 and about one-third of a million dollars was the value of the sand and gravel.

Just about one-half the stone was used for concrete and about one-tenth for flux. Rubble, riprap, road making, railroad ballast, flux and fertilizers make up the uses of the remainder. Practically the whole of the million tons of sand and gravel produced in 1917 went into construction work.

One of the largest quarries for crushed stone in the Chicago district is that of the United States Crushed Stone Co. at McCook, about one mile west of Summit. Unusual features in machinery, equipment and methods of production make this plant of exceptional interest to other producers everywhere and to consumers of crushed rock.

Summary

It is hoped that the reader will get some idea of the number and magnitude of the problems of chemical industry that are being solved in this region. Great as the development has been, it is only a beginning. Unequalled transportation facilities, a plentiful supply of fuel, space for development without a limit and a wonderful agricultural region to feed industrial populations are economic forces that are all working in favor of this district.

A dependable estimate of the total value of the industries in the Chicago-Gary district would be exceedingly difficult if not impossible to make. However, statistics are available which go to show that in Lake County, Indiana, and Cook County, Illinois, the value of the stone, lime, sand and gravel, clay products, mineral paint, pigments, cement, coke and steel reached easily the $300,000,000 mark in 1917. If statistics for the inorganic chemicals, the refinery products, the metallic products outside of steel and a number of smaller industries that could be classed as mineral were included, who knows but the estimate would be double?

Iron and Steel Plants Near Chicago

By Ernest Edgar Thum

GARY comes first to mind when thinking of ferrous metallurgical plants near Chicago, but it should not be forgotten that many years before Gary was planned a very large and modern plant was operated at South Chicago by the Illinois Steel Co. Perhaps it was a knowledge of the operating cost and technical results attained at South Chicago which impelled the big men of the Steel Corporation to locate the huge Indiana Steel Co. and its affiliated operations a few miles southeasterly on Lake Michigan. Half way between point of origin of Pennsylvania coal and Lake Superior iron ores, closely adjacent to tremendous bituminous fields in the North Central States, with ample fluxes and refractories close at hand, with a large industrial center near by to use as a labor reservoir, in the center of wide agricultural districts to be used as a food store, served by unexampled railroad facilities and by water transport second only to a highly developed ocean port, this situation is well nigh ideal for large-scale operations in steel.

The South Chicago works of the Illinois Steel Co. are somewhat congested and lack orderly arrangement owing to the fact that the company started many years ago and built its plant as the demand for its products increased. However, the concern is officered by men of most progressive ideas, and its metallurgical practice has always been of the best—witness the fact that its was the pioneer in the production of electric steels in quantity, and has recently developed the triplex process—converter to open-hearth to electric—to a large-tonnage commercial success.

The company's plants at Chicago, Joliet and Milwaukee include 17 blast-furnaces, 8 converters, 35 open-hearth, and 3 electric furnaces. Its pig iron is largely consumed in its own steel making operations, whose ingots are rolled in 26 rail, merchant, bar and structural mills, eventually finding a market as rails, sheets and shapes. Its rail mills are especially noteworthy, being equipped with every possible labor-saving device —indeed, the rolling of the heavy rails required by American roads would be utterly impossible without most adequate mechanical handling equipment.

Mechanical Handling of Ore at Gary

Mechanical handling, especially of incoming ore, is utilized to the fullest extent at Gary. The methods are indeed not unique, but well repay study by one not familiar with modern methods in getting a heavy raw material like iron ore from a huge lake steamer into bin or stockpile. From the time the iron enters the plant as ore until it leaves as shape or billet, it is treated by mechanical and metallurgical equipment installed on a grand scale. The engineers who planned the Gary works were indeed fortunate in being able to start from the ground up, in having almost unlimited money at their command, and the best technical talent as associates. In this way they were able to plan not a series of departments but a huge machine, each part so designed to fit into its neighbor with the smoothest mesh and least lost motion.

Statistics of this largest of steel plants are more or less dry reading. Twelve blast-furnaces, 46 open-hearth steel furnaces, 14 blooming, rail, plate and merchant mills, a 560-retort coke plant and a list of the auxiliary departments would not give any comprehension of the magnitude of their operations.

Near by are associated a large number of steel-using manufacturing establishments, such as the closely affiliated American Bridge Co. While structural fabrication is somewhat foreign to metallurgy, still this company's excellent forge and annealing equipment will be of interest to those not attracted by the systematic way a large column or girder is assembled from a score of miscellaneous pieces. Seven high-speed steam-hydraulic presses are used in forging bent pieces, ranging in capacity from 150 to 3000 tons, the latter capable of turning out solid or hollow forgings weighing up to 50 tons. Twelve annealing furnaces of modern design make up the equipment in this department.

Other Steel Companies

At Indiana Harbor, the Inland Steel Co. has two modern blast-furnaces in operation, one of which is interesting in that it ran 5 years on its last lining, producing approximately 1,000,000 tons of pig. Molten iron is delivered to twelve 60-ton basic open-hearth furnaces, and the resulting steel ingots are rolled in a 36-in. blooming mill and a variety of smaller mills to a number of different shapes. Production at this plant approximates 1,000,000 tons of steel per annum, exclusive of the tonnage of small sections which have been produced at its Chicago Heights works since 1893.

In this same vicinity (South Chicago) the International Harvester Co. operates 3 blast-furnaces, with a yearly production of 450,000 tons of pig iron, a bessemer converter and a 35-in. blooming mill, 3 merchant bar mills and a shafting mill with a combined output of 350,000 tons of finished shapes.

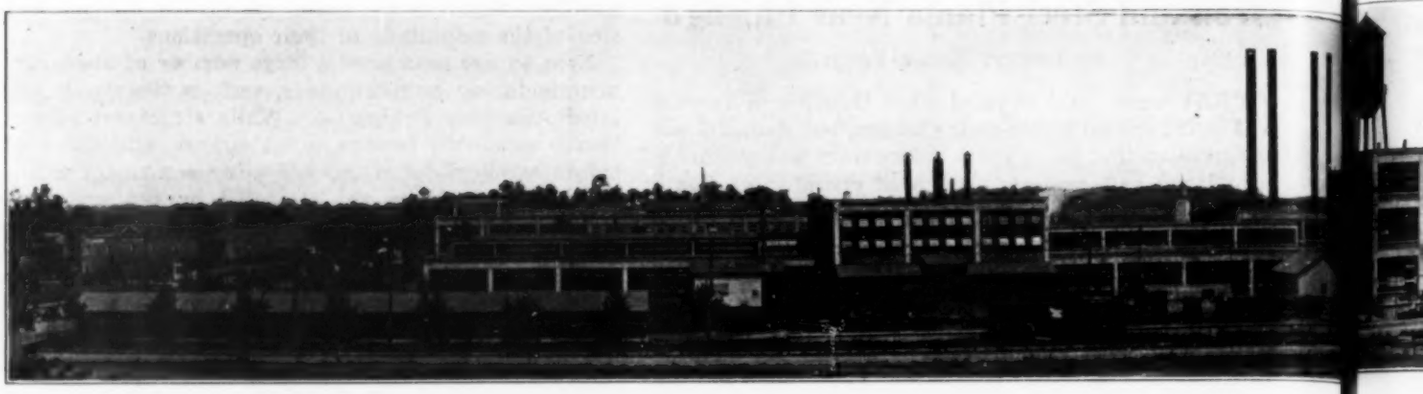
The Mark plant of the Steel & Tube Co. of America, at East Chicago, has only one blast-furnace, capacity 600 tons, but this is the largest in the country, being 15 per cent greater than any other. Steel is produced in open-hearth furnaces and is principally made into plates. The 30-in. universal plate mill holds a record for rolling more than 17,000 tons of plates in a month. The main mill tables are designed to shear plates. The mill is served by four 4-door regenerative heating furnaces.

This completes the list of steel companies which produce iron direct from ore in blast-furnaces. Several other concerns in this vicinity operate open-hearth furnaces, using scrap, cold pig and ore as their iron-bearing materials, while others, such as the Republic Iron & Steel Co. at East Chicago, produces a very sizable tonnage of merchant shapes from fagoted scrap.

Alloys and Castings

Among several companies, each of which deserves special attention, not possible in such a brief résumé of the subject, may be mentioned the three plants of the Interstate Iron & Steel Co., at South Chicago, Grand Crossing and East Chicago, specializing in alloy steels; the Hubbard Steel Foundry Co., at East Chicago, notable for high quality steel castings; the American Steel Foundries Co., and Standard Forgings Co., at Indiana Harbor, with a combined monthly output of 13,000 tons of car and locomotive parts and axles.

The Crane Co. operates two bessemer converters and one electric furnace; it is the largest manufacturer of valve iron in the world and during the war handled 700 tons of iron and steel a day in its three Chicago plants.



Natural and Industrial Resources of Indiana

A Description of Some of the Mineral Resources and a Review of Some of the Chemical Industries of Indiana—Importance of the State's Organic Chemical Plants and of the Work in Their Research Laboratories

Raw Materal Resources of Indiana

By W. N. Logan, Ph.D.
State Geologist

From a commercial standpoint the ideal State would be the one whose resources permitted it to supply its own needs. But it is a fact well established that no State lives to itself alone. But if during a world cataclysm such as we are experiencing an impenetrable barrier should be built about Indiana, the diversity of her natural resources and her manufacturing industries would enable her inhabitants to go forward toward the goal of self-preservation and self-realization. For Indiana has been favored with natural resources the variety, value and abundance of which are not realized by a large part even of her own citizens. In case of extreme isolation, Indiana could produce for her own needs enough coal, petroleum and its products, gas, iron, building stone, lime, cement, salt, fertilizers except phosphate, paint pigments, mineral dyes and by an expensive process aluminum. She would be without copper, nickel, lead, zinc, silver and platinum, though she could probably produce enough gold for front teeth filling.

The advance made in the utilization of some of these resources has been rapid, yet after more than a century of existence as a State many of its mineral resources remain latent or only meagerly developed.

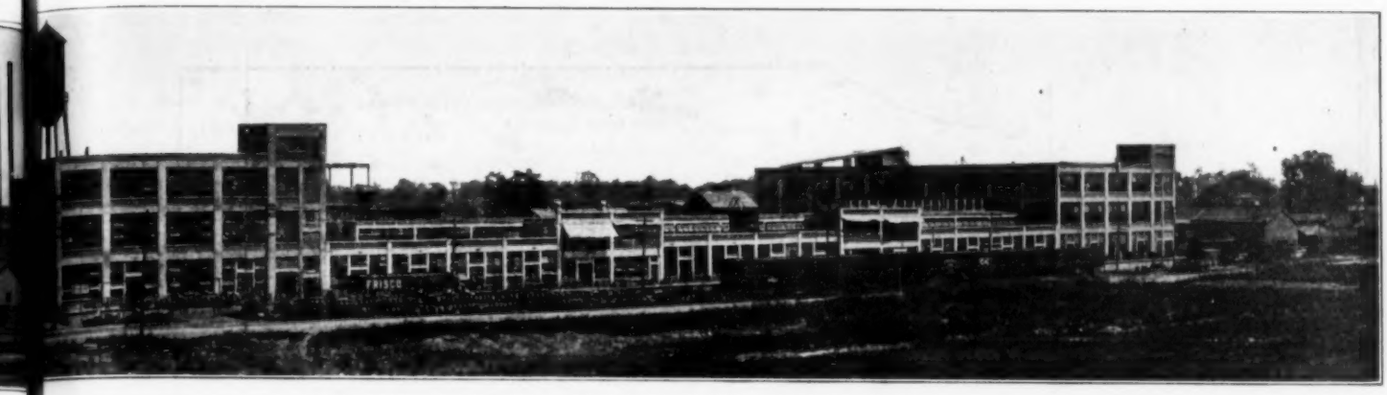
Fuel

Because of the dependence of manufacturing and industrial development on fuel, this resource is of primary importance, and Indiana's possessions in coal, petroleum and natural gas place her in a position of great economic independence. Of coal, Indiana produces annually its five tons per capita, the per capita consumption of the United States, and a surplus of nearly two and one-half million tons. The coal beds of Indiana occupy an area of approximately 7000 sq.mi. in the western and southwestern parts of the State. One or more beds underlie the whole of sixteen counties and parts of ten others. According to Ashley the total amount of coal in Indiana approximates 50 billion tons. Of this amount more than 13 billion tons is workable. The total amount which has been mined is about one-half billion tons. Approximately 17½ million tons are being mined each year, with a yearly increase between ¼ and ½ million tons. The coals of Indiana rank well among the bituminous coals of the Interior basin. They contain a high moisture and volatile matter content and only a medium ash and sulphur content. Although belonging to the bituminous division, they contain a variety of high fuel value for domestic use called "block" coal because its laminated and jointed condition causes it to break up into large blocks; also a variety of cannel coal, which is a good gas producer. There are more than thirty beds of coal, nine of which are workable. The average thickness of the vein known as No. 5 is about 5 ft., and a maximum thickness of more than 10 ft. has been recorded. Indiana ranks sixth in the production of bituminous coal. One of its mines holds the world's record for the production of bituminous coal from one mine in a single day. The American mine located at Bicknell, Knox county, on Feb. 8, 1919, mined and loaded 6128 tons on 128 railroad cars in 8 hours.

Petroleum

A large amount of the petroleum produced in Indiana has come from the Indiana portion of what is known as the Lima-Indiana oil field. This includes, in Indiana, portions of Grant, Blackford, Huntington, Wells, Adams, Jay, Delaware, Madison and Randolph counties.

This field reached its highest production in 1904, when over 11 million barrels were produced in the State, the larger part from this field. The annual production for the State is still in excess of one and one-third million barrels. The southwestern Indiana field, extending from Martin county through Daviess, Pike and Gibson counties, is becoming an important field and will probably be extended. Sullivan county contains an area which is producing both oil and gas. The oil in the Lima field is obtained from the Trenton limestone. In the northern and southern parts of the State some oil is obtained from the Corniferous and in the southwest-



ern portion from the Mississippian and the Pennsylvanian formations. Wells are being drilled on untried territory in Martin, Monroe, Lawrence, Jackson, Jennings and other counties. Much untried territory lies in the State, but it is possible to determine the structural conditions only in the non-glaciated region.

Natural Gas

The largest natural gas area in Indiana lies in the eastern portion of the State, in the counties of Delaware, Blackford, Jay, Madison, Hancock, Henry and Randolph. Gas has recently been obtained from wells in Lawrence county and in the southwestern oil field in Pike and Gibson counties. The eastern gas field of Indiana reached the peak of production in 1902, when the value of the gas produced was more than 7 million dollars. At the present time the value of its production is somewhat under one million dollars. Much untried territory exists in the State and lends encouragement to the hope that production may again soon be on the increase.

The largest amount of gas has been found in the Trenton sands. Some has been obtained from the Corniferous, some from the Mississippian and some from the Pennsylvanian rocks.

Peat

Many of the shallow lakes, marshes and ponds which were left on the surface of northern Indiana following the retreat of the glacial invasion were later filled with an accumulation of vegetable matter. This vegetable matter was gradually transformed into peat, the so-called first stage in the formation of coal. The workable peat beds cover approximately 36,000 acres and contain nearly 3 billion cu.ft. Enormous fuel values are represented in this resource, as well as mull, which may be used as an absorbent, packing material, deodorizer, fertilizer filler, in the manufacture of gas, coke and ammonia.

Cement

Indiana ranks second among the States in the production of cement, producing more than three times as much as it consumes, though it consumes annually more than one barrel per capita. Portland cement is the principal kind produced, but a small amount of natural cement is manufactured. There are five active plants, located at Buffington, Stroh, Syracuse, Speed and Mitchell, and one under construction at Limedale. The materials used are surface clays, marl from the lakes, slag from the iron smelters, hydraulic limestone from the Devonian formation and shale and limestone from the Mississippian formation. With the present capacity, under normal conditions the production of cement in Indiana would exceed 10 million barrels.

Building Stone

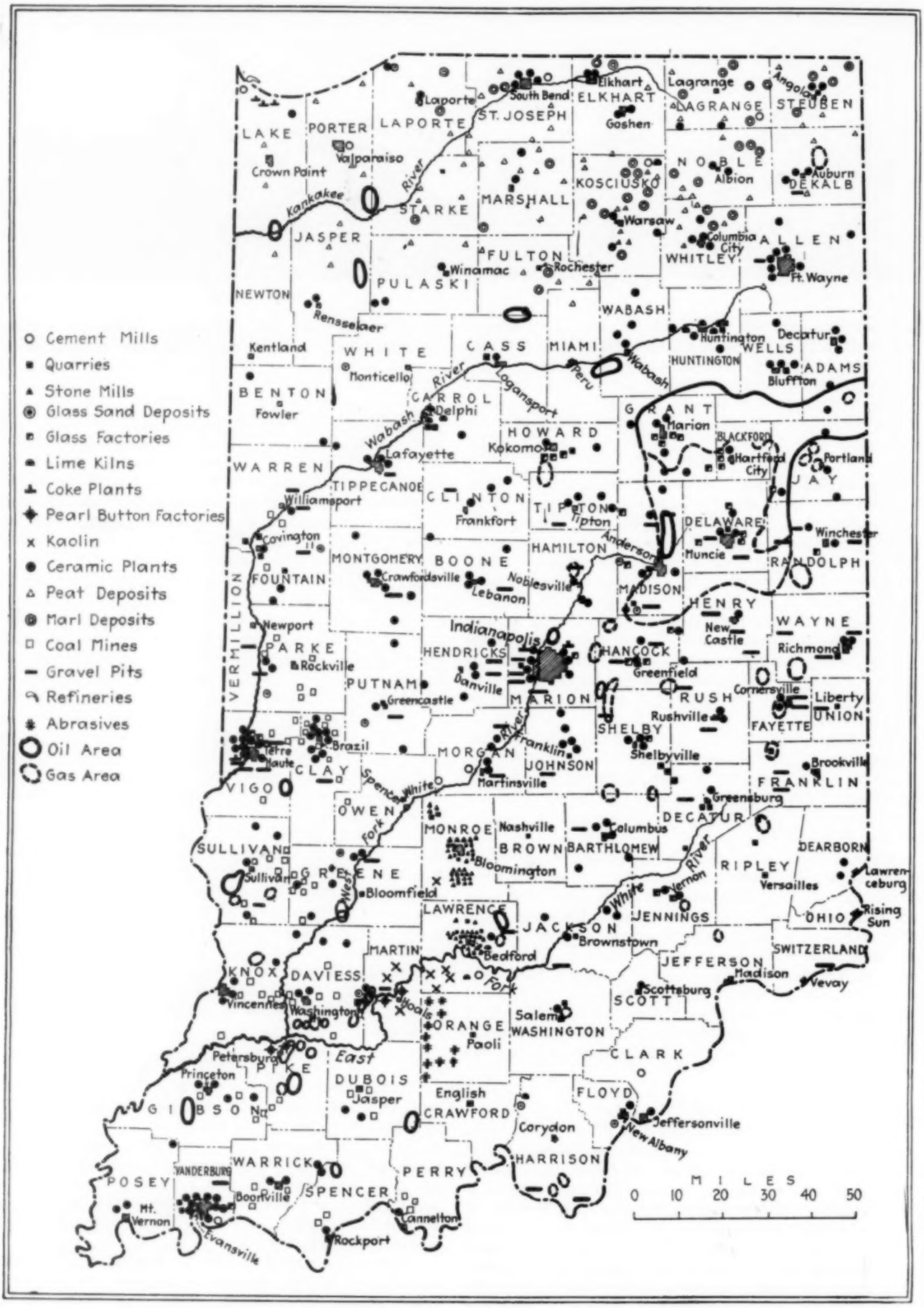
Indiana has attained an enviable position among the States of the Union as a producer of high-grade building stone. The oölitic limestone from the Salem formation, which is known as Indiana, Bedford or oölitic limestone, is highly praised by architects and builders and is widely used in the erection of both public and private buildings. Its uniform gray color, fineness of grain, freedom from planes of weakness, ease of carving, strength and durability recommend it to the builder. The best grades contain from 98 to 99 per cent of calcium carbonate and possess a crushing strength of 7000 lb. per sq.in. Two of the counties, Lawrence and Monroe, contain 36 large quarries which produce more than 70 per cent of all of the limestone used in the United States for building purposes. Fifty-five large mills prepare the stone for the market, handling more than 10 million cu.ft. per year. A recent order received by these mills includes enough dressed stone to fill 700 cars. The value of the stone for this contract is a little under one million dollars and it all goes into a single building.

The Indiana oölitic limestone has been used in nearly every State in the Union. It has been used in at least five State Capitol buildings, Indiana, Illinois, Georgia, New Jersey and Mississippi. The area occupied by this stone extends from Putnam county to the Ohio River, and its outcrop varies in width from a few rods to 14 miles. Its maximum thickness is about 100 ft. The Niagara limestone is a bedded stone which is quarried extensively in Indiana and is used for flagging, curbing, foundations, ashlar, piers, abutments and other purposes.

Ceramics

Indiana produces a variety of ceramic wares, common, front, vitrified, ornamental and fire brick, totaling in value about 350 million dollars annually. Drain tile, encaustic tile, fireproofing, terra cotta, sewer pipe and stove lining are other important products. Pottery products manufactured are red earthenware, stoneware, yellow and Rockinham ware, white ware, C. C. ware, white granite, semi-porcelain, sanitary ware and porcelain electrical ware.

Indiana ranks sixth in ceramic production. The materials used in this industry in Indiana are the Knobstone shales, the Chester shales, the shales of the Pennsylvanian formation, the under or fire clays, gla-



MAP SHOWING DISTRIBUTION OF ECONOMIC PRODUCTS AND INDUSTRIES OF INDIANA

cial till and kaolin. The Chester shales are used only to a limited extent, but their quality warrants a much more extensive utilization. The Pennsylvanian shales are used at Terre Haute in the manufacture of hollow block building tile, radial chimney blocks, partition tile, flue linings, drain tile, roof tile and paving brick and for many other purposes.

At Brazil the clay plants use fire clay from under the coal in the manufacture of front brick, sewer pipe, conduits, silo blocks, interlocking glaze tile and hollow blocks.

Some glacial till and shale are also used. The Knobstone shales are used at Martinsville, Brooklyn and other places. Surface clay and glacial till are used in the northern part of the State in the manufacture of drain tile and some other products.

Lime

Both quick and hydrated lime are manufactured in Indiana.

The limestones used for the manufacture of lime include the Niagara, the Mitchell and the Salem. There are other limestones, such as some of the limestones of the Chester group, which are suitable and have been used locally for lime. There are also deposits of marl which could be used for this purpose. The lime produced in Indiana is used in a number of industries, for building lime, glass manufacture, chemical lime, paper manufacture, sugar refining, tanning and agriculture. The production exceeds 100,000 tons per year. A portion is magnesian lime and a portion high calcium lime.

The Niagara limestone contains from 50 to 53 per cent of calcium carbonate and from 7 to 45 per cent of magnesium carbonate. The average of 5 samples contained 66.12 per cent of calcium carbonate and 26.38 per cent of magnesium carbonate.

The Salem or oölitic limestone contains for an average of five samples 98.11 per cent of calcium carbonate and 0.84 per cent of magnesium carbonate. The Mitchell limestone contains for an average of five samples 98.06 per cent of calcium carbonate and 0.45 per cent of magnesium carbonate.

Gravel and Sand

The invasion of ice during the glacial period left in its wake in Indiana not alone destroyed or reversed drainages but large quantities of sand and gravel which have been of great value to the State. Building sand, ballast sand, foundry sand, glass sand, paving and other sands are well distributed and the production is more than 3½ million tons a year. The annual production of gravel exceeds 2½ million tons, the greater part of which is obtained from the glacial deposits. In the unglaciated region some gravel is obtained from the Mansfield grit and from residual chert gravels produced by the weathering of the bedrock formations. Many of the streams which cross the non-glaciated area have their valleys filled with sand and gravel carried from the glaciated area.

This valley filling amounts in places to more than one hundred feet.

Marl

A secretion of white calcium carbonate, secreted largely by the plant Chara, accumulates on the floors of the lakes in Indiana and forms, with a slight mixture of clay and fine sand, beds of marl. The area extent of the available marl beds of Indiana is approximately 7500 acres containing approximately 137,133,333 cubic yards.

A COAL MINE WHICH PRODUCED 128 CARS, 6128 TONS, OF COAL IN 8 HR.—THE AMERICAN MINE AT BICKNELL, KNOX COUNTY, INDIANA

The marls of Indiana furnish the calcium carbonate used in the manufacture of portland cement. They are suitable for the manufacture of quicklime, agricultural lime and other purposes.

Kaolin

A variety of halloysite called "Indianaite" occurs in more than half a dozen counties. The most important deposits are found in Martin and Lawrence counties. The kaolin has been used in the manufacture of ceramic wares, alum cake and for other purposes. A part of the deposit consists of a pure crystalline variety, but a great deal of it is stained a mahogany red by iron oxide.

The white kaolin is suitable for use in the manufacture of paper, paint pigments, ultramarine, filters, absorbents and buffing powders. The kaolin occurs at several horizons in the Mississippian formation and at the contact between the Mississippian and the Pennsylvanian formations.

Mineral Waters

There are many important mineral springs in Indiana. About 20 of them sell about $500,000 worth of water per year.

At seven of the springs there are hotel accommodations for more than 2500 persons. Much of the water is sold for medicinal use. Favorite watering places are French Lick, West Baden, Trinity Springs and Martinsville.

Other Resources

A fine grade of oil stones is produced from the sandstones of the Chester and the Mansfield groups. A factory for the manufacture of oil stones is located in the northern part of Orange county. Potash has been manufactured from shale in Clark county, but production is still in the experimental stage. Pyrite from which sulphur is obtained is a by-product of the mining of coal and may be obtained from shales. Paint pigments occur in limited quantities. A little gold and some precious stones have been obtained from the glacial drift in a few counties.

Chemical Industries of Indiana

By F. O. Anderegg

IN THE Hoosier State industries of an organic nature are most numerous and important. Of the organic chemical concerns in Indiana the pharmaceutical industry stands out rather prominently, and of the several companies engaged in this industry Eli Lilly & Co. of Indianapolis does the biggest business. It manufactures a complete line of pharmaceutical products and several alkaloids such as emetine, colchicine, hydrastine, cephæline, sanguinarine, etc. It has made nearly all the atropine sulphate used in this country and in England during the war from jimson weed by a process of its own. This company also has a large biological department where a great variety of serums and antitoxins are made and distributed.

Eli Lilly & Co. has long appreciated the benefits to be derived from a research department and has equipped a fine building for its use. The science building is provided with an excellent assembly room for use of salesmen's schools and meetings of employees; it is available also for the use of local scientific societies which from time to time are invited to be the guests of this firm. An excellent library devoted largely to chemistry, physiology, botany, experimental medicine and other lines cognate to pharmacy is maintained for the use of the scientific staff.

Lilly & Co.'s Chemical Laboratories

The second floor of the building is occupied by admirably equipped chemical laboratories for analytical and research work. Each analyst has an alcove which is practically a complete chemical laboratory in itself. Additional apparatus like balances, polariscopes, spectroscopes, refractometers, etc., are in specially built rooms readily available for use. A well-equipped electrochemical laboratory is installed on this floor. On the third floor there is a department of experimental medicine where the drugs and chemicals which cannot be standardized chemically are tested physiologically upon selected lower animals. Investigations are conducted extending over long periods of time having for their purpose the determination of the deterioration and keeping qualities of various pharmaceutical products. Laboratory research work on synthetic drugs

BACTERIOLOGICAL LABORATORY, BIOLOGICAL DEPARTMENT, SWAN-MYERS CO., INDIANAPOLIS

CULTURE MEDIA LABORATORY, BIOLOGICAL DEPARTMENT, SWAN-MYERS CO., INDIANAPOLIS

constitutes an important portion of the activity of the department of experimental medicine. The science building also provides quarters for an interesting laboratory for synthetical chemical research. With the installation of a noted expert in colloids this firm is preparing to carry on extensive research in the theoretical and practical development of this extremely important branch of chemistry.

As the inspection of crude vegetable drugs is a very important work in handling the enormous quantities of materials such as are necessary in manufacturing operations, the Lilly laboratories have maintained for the last 25 years an excellent botanical department which has quarters in the science building. The botanical laboratory proper contains large collections of authentic crude drug specimens, identified adulterations, substitutes, also standard herbarium specimens and an extensive collection of microscopic preparations of vegetable drugs. A conservatory is on the same floor for the purpose of propagating seedlings used in the study of medicinal plants and in work upon plant breeding. The botanical department, in addition to being charged with the inspection of crude drugs purchased for manufacturing, has also the supervision of extensive tracts of ground employed in raising drugs, and especially in experiments in drug plant breeding, with a view to improving the quantity of the medicinal principles.

Other Leading Concerns

Another important concern also located in Indianapolis is the Swan-Myers Co. This firm manufactures a very complete line of pharmaceutical products which are used by the medical profession and by veterinaries. It also prepares a full line of biological products of a bacterial nature. The firm's products are sold throughout both Americas. The Pitman-Moore Co. is also located in the capital city and is engaged in the same sort of business, making a specialty of veterinary biological products. Other pharmaceutical concerns are the McCoy-Howe Pharmacal Co. of Indianapolis, the Lafayette Pharmacal Co. in the city of that name and the Central Pharmacal Co. of Seymour. Since the supply of chemicals from Germany has been cut off the Inland Alkaloid Co. of Tipton has perfected a number of processes for the manufacture of some of the mydriatic alkaloids. It has made notably large quantities of

atropine sulphate from stramonium or jimson weed. Its products are sold only through wholesalers.

Other Products Keep Firms Busy

The Mishawaka Woolen Manufacturing Co. is engaged in making woolen and rubber footwear and is solving some interesting chemical problems in making its goods wear longer and stand better the disintegrating effects of time.

Varnish and similar products are made by the well-known concern of South Bend, the O'Brien Varnish Co.

The Dodge Manufacturing Co. of Mishawaka has been engaged 100 per cent in war work. Besides manufacturing marine engines, gun carriages, conveyor systems for powder plants, it has been making aëroplane parts, using a waterproof adhesive developed in its own plant and used in the construction of plywood. This plywood was used on the wings and fuselages of aëroplanes by both the Army and Navy. There is reason to believe the NC boats were made complete with Dodge veneer. This development grew out of trunk manufacture.

There are several plants distributed throughout central Indiana for the manufacture of strawboard. There is usually a large demand for this product, and the supply is limited only by the amount of raw material available.

Starch, glucose and by-products are made by the Union Starch & Refining Co. of Edinburgh.

There are many concerns engaged in the canning business. The most prominent of these is the Van Camp Co. of Indianapolis, which is also most interested in chemical control and development work. A good example of the soft drink manufacture is the Centlivre Beverage Co. of Fort Wayne, which makes the well-advertised drink called "That's it."

This city is also the home of the Rub-No-More soaps.

One of the most interesting firms engaged in organic chemical industry has been the Commercial Solvents Co. of Terre Haute, which has been using a unique method for producing acetone by the fermentation of carbohydrates which yield ethyl alcohol as the most important by-product.[1]

The Prest-O-Lite Co. of Indianapolis is engaged in the manufacture of products of an organic as well as electrochemical nature. The name, Prest-O-Lite, has been associated with automobile service for many years. The use of acetylene for lighting and its wider application in oxy-acetylene welding are well known. The gas from the action of water on carbide is dissolved in acetone and stored in steel cylinders packed with a charcoal and asbestos filler. The cylinders are manufactured in sizes suited to various uses. The phenomenal growth of the Prest-O-Lite battery plant is indicative of the favor it has won with the public for automobile starting and lighting uses. During the past three years the plant floor space has increased nearly ten times. A proposed addition during 1920 will bring the total to 280,000 sq.ft. It is anticipated that the increase in facilities will enlarge the capacity to about 3500 batteries per day by the end of this year. The lighting and starting batteries are employed as standard equipment on 35 makes of motor cars and trucks. The elements consist of Faure type plates. In their manufacture lead oxide paste is applied to lead antimony grids. After a period of "setting" in dilute sulphuric acid, during which the oxide is largely changed to sulphate, the positive plates are converted to lead peroxide and the negative to lead sponge by electrolysis. The positive and negative groups are assembled with wood separators of maximum porosity, thus preventing the lessening of capacity at low temperatures, as happens when partially porous material such as perforated hard rubber is used.

About 20 years ago Indiana ranked second among glass-producing States. With the decrease in supply of natural gas this industry suffered, although with the introduction of labor-saving machinery during the last few years it has begun to advance again. Two important firms making glass are the Ball Bros. Glass Co. of Muncie, which makes a specialty of glass jars for household use, and the Fairmount Glass Works of Indianapolis, which makes a variety of glass bottles.

The United States Encaustic Tile Co. of Indianapolis makes some very beautiful decorative art mosaic, tiles and bricks.

Cement

Located at Mitchell in the southern part of the state are two 10-kiln plants of the Lehigh Cement Co. with a capacity of two and a quarter million barrels of cement a year. The raw materials are from the Mississippian formation and include the massive Mitchell series limestone and the Knobstone (or New Providence) shales. These rocks are made into a cement which is notable for its whiteness and is in special demand for sidewalks and curbing.

This Mitchell limestone is of a very high quality, running consistently better than 96 per cent pure calcium carbonate. It is made into high-grade chemical and hydrated lime by the Mitchell Lime Co. of Chicago. The purity of this material makes a very even slaking lime well adapted for a great variety of chemical reactions. In making the hydrated material exactly the right amount of water is scientifically added. Then the very finely divided hydroxide is separated from any grit by air separation and is packed in 50-lb. sacks, which are very carefully sealed, preventing appreciable deterioration. The company's products are used very successfully in the manufacture of soap, paper, rubber, varnish, insecticides, also in oil refining, the dehairing of hides, sanitation and water purification.

A very interesting alloy is made at Kokomo by the Ellwood-Haynes Stellite Co. It contains cobalt and chromium somewhat analagous to nichrome and seems to have many of the properties of that alloy in regard to its resistance to the action of most chemicals. But it has other unique properties, the most important of which is its extreme hardness. Stellite does not lose its characteristic hardness even at red heat, making it probably the best high-speed tool metal known. Its chemical and electrical properties are being tested in the laboratories of the Purdue University, and it offers promise of many useful applications in both of these industries.

A good example of the testing laboratories of the State is furnished by the Fort Wayne Testing Laboratory Co., which carries out a great variety of chemical and physical tests and plant control experiments involving metals, fuels, foods, cement, water, etc.

The chemical industries of the northwestern part of the State are not taken up in this article, since they belong with the Chicago district as described in an article elsewhere in this number.

[1] *J. Ind. Eng. Chem.*, 11, 723, gives an account of this process.

Natural and Industrial Resources of Michigan

General Review of the Mineral, Metallurgical and Chemical Industries — Leading Products Include: Iron, Copper, Salt, Alkalis, Halogens, Lime, Gypsum, Cement, Abrasives, Silica, Sugar, Paper, Dyes and Organic Chemicals

Mineral Resources of Michigan

By R. A. Smith

MICHIGAN is one of the foremost States in the production of minerals and mineral products. She produces about thirty different mineral products. The total value of these in 1917, exclusive of pig iron, was $185,511,101, and the value of pig iron shipped was $18,300,501. The production of copper amounted to 268,508,091 lb., valued at $75,622,256, and the shipments of iron ore amounted to 17,839,548 tons, valued at $60,508,942. The total value of copper and iron was $136,131,198, or nearly 74 per cent of the total value of the mineral products for the State.

The chief mineral products next in order of importance were salt, 16,078,136 bbl., valued at $6,877,202; portland cement, 4,688,899 bbl. shipped, valued at $6,122,887; coal, 1,374,805 tons shipped, valued at $4,426,314; limestone and lime sold $4,213,587; brick and tile products, $2,846,264; sand and gravel, $1,641,748; and gypsum, 375,803 tons mined and gypsum products sold, $1,568,655.

The other less important mineral products in order of value are silver, bromine, sand-lime brick, calcium chloride, mineral waters, grindstones and scythestones, potash, trap rock, glass-sand, quartz, clay, sandstone, petroleum, natural gas, marble, graphite, precious stones, mineral paints.

In 1917 Michigan held first rank in the production of salt, bromine, calcium chloride and sand-lime brick; second in iron ore and grindstones and scythestones; third in copper, gypsum and gypsum products; fourth in limestone and lime; sixth in sand and gravel, and eighth in portland cement.

The development of some of the mineral resources began early. The production of coal began as early as 1836, copper in 1845, iron ore in 1850, salt in 1859, and gypsum in 1860. The quarrying of limestone for burning lime began in Monroe county almost with the settlement of Detroit in 1701. The development of some of the other mineral products was comparatively recent —sand-lime brick about 1903, potash as a by-product of the portland cement industry in 1917, and marble in 1918. Michigan contains other mineral resources as yet undeveloped—feldspar, pyrite, slate, granite, celestite—and many of the other resources are susceptible of much greater development.

Iron Ore

The iron ores of Michigan are chiefly hematite, but there are some limonitic ores. The iron ore districts are located in the Northern Peninsula. The ore is produced in six districts, which in order of importance are: the Gogebic, Gogebic county; the Marquette, Marquette county; the Iron River, Iron county; the Menominee, Dickinson county; the Crystal Falls, Iron county, and the Gwinn, Marquette county. The total shipments of iron ore in 1917 amounted to 17,839,548 tons, of which the Gogebic Range contributed 7,003,838 tons, the Marquette 3,959,103 tons, the Iron River 2,525,741 tons, the Menominee 1,975,096 tons, the Crystal Falls 1,454,667 tons and the Gwinn 921,103 tons.

The total ore reserves Jan. 1, 1917, were estimated at 196,750,502 tons, of which 83,721,570 tons were developed ore, 107,954,081 tons prospective ore, and 5,132,343 tons ore in stock.

In 1916, 4,801,856 tons, or 25.4 per cent of the ore shipped, was of bessemer grade. The Gogebic Range contributed 3,933,594 tons, or 81.9 per cent, of the total bessemer ore produced, the Marquette Range (including the Gwinn District) 690,283 tons, or 14.4 per cent, and the Menominee 177,979 tons, or 3.7 per cent.

The average iron content of the ore as shipped was 53.03 per cent for the Gogebic, 52.43 per cent for the Marquette and 51.62 per cent for the Menominee Range.

Copper

Prior to 1883 Michigan had produced 80.2 per cent of all the copper produced in the United States. In 1887 she was surpassed in production by Montana and in 1905 by Arizona. From 1845 to the close of 1917 Michigan produced 6,366,506,339 lb. of copper, or 25.27 per cent of the total production of copper of the country during this period.

The copper range extends from the northern extremity of Keweenaw Peninsula southwest through Keweenaw and Houghton counties into Ontonagon county. Copper-bearing rocks also occur on Isle Royale, in Lake Superior. The copper-bearing series comprise a thick succession of lava flows and interbedded sandstones and conglomerates. The copper deposits are unique in that they are the only large deposits in the United States in which the ore occurs chiefly as the native metal. The copper occurs in the cellular portions of the lava flows and in some of the beds of standstone and conglomerate and certain shales.

Most of the lodes are low grade. The average content of copper recovered from the ore treated in 1917 was less than 1 per cent. The copper values, however, are relatively uniform in the lodes. This, together with the high concentration possible with native ore and the low cost of refining, makes the mining of such low-grade deposits profitable.

Salt

The salt resources are inexhaustible and comprise natural brines and beds of rock salt. Natural brines occur in several rock formations. The brines from the Marshall sandstone have been utilized most extensively in salt manufacture in Saginaw Valley. Formerly this region was the center of the salt industry. It was carried on in connection with the lumber mills, but with the decline of lumbering it has become relatively unimportant. The Marshall brines contain considerable per-

IRON ORE AWAITING SHIPMENT AT PRINCETON MINE

centages of earthy chlorides and an appreciable content of bromine. These brines are the source of all of the bromine and calcium chloride produced in Michigan.

The chief salt-producing district is along Detroit and St. Clair rivers, but the Ludington-Manistee district is also an important producer. Salt is produced from artificial brines derived from underlying beds of rock salt. In the Detroit-St. Clair rivers district, the rock salt beds have an average aggregate thickness of over 400 ft. In the Ludington-Manistee district the aggregate thickness of the beds is less than 50 ft. More than 800 ft. of rock salt was penetrated in a well at Onaway and over 300 ft. at Grand Lake, Presque Isle county. Salt was also struck at Alpena, Alpena county. The salt resources of these counties, though unlimited, have not been utilized.

Limestone

Michigan has very large deposits of limestone. Unfortunately most of the deposits are located in the northern part of the State relatively distant from large markets. Many of the deposits, especially in the Southern Peninsula, are on or near cheap water transportation, and this partially compensates for the distance from markets. Only a few important deposits of commercial limestone occur in the southern half of the State.

The principal limestone district of the Southern Peninsula extends across the northern end of the Peninsula from Thunder Bay to Little Traverse Bay. In the Northern Peninsula, the deposits form a belt from 10 to 15 miles wide extending from Menominee county on the west along the northern shores of Lake Michigan and Lake Huron to Drummond Island. There are numerous very large and many smaller exposures of limestone in both districts. The limestone varies in composition from nearly pure calcium carbonate to calcium-magnesium carbonate or normal dolomite. The deposits along the shore of Lake Huron in Presque Isle county are remarkable not only for their extent and thickness but for their very high average purity. The greater part of the limestone belt adjacent to the lake shores in the Northern Peninsula is characterized by high magnesian limestones or dolomites. Some beds are very pure, but others are very siliceous. The northern part of the belt contains several relatively thick high calcium beds of limestone interbedded with light to heavy magnesian limestone.

In the Southern Peninsula limestone is quarried on a large scale at Sibley, near Detroit; near Bayport, Huron county; at Alpena and Rockport, Alpena county; near Rogers, Presque Isle county, and along the south side of Little Traverse Bay. An important quarry is operated at Bellevue, Eaton county. In the Northern Peninsula large quarries are operated at Manistique and near Blaney, Schoolcraft county; at Hendricks and Fiborn and east of Trout Lake, Mackinac county.

The stone is used chiefly for flux, chemical purposes, commercial lime, portland cement, carbide, road metal, concrete aggregates, ballast, etc. A large tonnage of low-silica stone is produced at Rogers, Presque Isle county, for fluxing purposes.

Marl or Bog Lime

Marl or bog lime occurs in hundreds of lakes and swamps in Michigan. The deposits vary in size up to several hundred acres and to 50 ft. or more in depth. Many deposits contain an average of more than 90 per cent of calcium carbonate, but others are very impure. Though only a small portion of the deposits have been investigated, the aggregate area of proved marl deposits is over 27,000 acres.

Most of the early cement companies in Michigan used marl, but, because of cheaper operating costs, they have since changed to limestone wherever possible. The use of marl for correcting sour or acid soils promises to become of considerable agricultural importance.

Coal

The coal basin underlies the central portion of the Southern Peninsula. In the early days of the coal industry producing areas were in the vicinity of Jackson, Jackson county; Owosso, Shiawassee county, and Grand Ledge, Eaton county. In 1897 the development of the coal deposits in Saginaw Valley began and now most of the coal is produced in Bay, Saginaw and Tuscola counties.

There are a number of coal beds, but most of them are too thin to mine under present conditions. The minable coal occurs in small basins or troughs varying from 100 to 2000 acres or more. The coal is a high volatile non-coking bituminous coal. It is an excellent domestic and a good steam coal.

Gypsum

Large deposits of gypsum occur in the vicinity of Grand Rapids and Grandville, Kent county; in Iosco and Arenac counties, and in St. Ignace Peninsula and to the eastward on St. Martins Island, Mackinac county. Beds of gypsum apparently of commercial thickness and extent are also reported in Tuscola, Eaton and Ionia counties. The deposits are extensively developed in the Grand Rapids-Grandville district and at Alabaster, Iosco county. There are numerous beds in each district and several are of workable thickness. The largest beds are about 25 ft. thick. A portion of the crude gypsum is ground for land-plaster but most of it is calcined for stucco, mixed wall-plasters, plaster board, building block, calcimines and other gypsum products.

Sand and Gravel

The sand and gravel deposits of Michigan are inexhaustible. The most important deposits occur in ridges known as "hogbacks" or eskers, in irregular hills called kames, and in outwash plains, deltas, and beach ridges—features resulting from water action during the last glacial invasion. Large deposits occur in nearly every locality. In the vicinity of industrial cen-

ters and along lines of rail and water transportation, the deposits have been extensively developed for general building purposes and concrete construction. Hundreds of gravel deposits have been developed for road building.

Silver

Silver occurs in the deposits of native copper, chiefly as intergrowths of the two metals. The entire production of silver is derived from the copper ores.

Bromine

The brines of the Marshall and Berea sandstones contain appreciable quantities of bromine. All of the bromine, however, is produced in Saginaw Valley from Marshall brines in connection with the salt and chemical industries. The chief centers are Midland, Saginaw and St. Charles. In 1917 Michigan produced 82.2 per cent of the bromine produced in the United States.

Calcium Chloride

The Marshall brines, in addition to bromine, contain considerable percentages of calcium chloride. This is recovered as a by-product of the salt and chemical industries in Saginaw Valley. In 1917 this region produced nearly three-fourths of the calcium chloride produced in the United States. The chief centers are at Midland and Saginaw.

Potash

A considerable amount of potash is derived from leaching wood ashes, but in 1918 the production of potash as a by-product of the portland cement industry began at Newaygo, Newaygo county. There are large possibilities for a much greater production from the other portland cement plants which have not yet provided for the recovery of potash from escaping flue dust.

Mineral and Spring Waters

At Mt. Clemens, Ypsilanti and Detroit mineralized waters are produced in large quantities for bathing and medicinal purposes. Mineral and spring waters are also produced at a number of other places in the State. Some of the mineral waters are strongly mineralized and compare favorably with other famous mineral waters.

Grindstones and Scythestones

Grindstones and scythestones are produced in large quantities from certain beds of sandstone in Huron county. There are large deposits in the vicinity of Grindstone City and Port Austin.

CRUSHING PLANT AND STORAGE PILE OF THE MICHIGAN LIMESTONE & CHEMICAL CO. AT CALCITE

CLEVELAND STONE CO. WORKS AT GRINDSTONE CITY—SEAT OF GRINDSTONE AND SCYTHESTONE INDUSTRY IN MICHIGAN

Trap Rock

There are inexhaustible deposits of trap rock in the western part of the Northern Peninsula. Crushed trap rock for road metal and concrete aggregates is produced at Marquette and Negaunee, Marquette county. A large amount of trap rock is produced in connection with copper mining. The marketed production, however, is small because of the remoteness of the deposits from large markets.

Glass-Sand

Large deposits of pure white silica sandstone occur in Wayne and Monroe counties. The sandstone is quarried, crushed and washed for glass-sand at Rockwood, Wayne county, and near Steiner, Monroe county. The sandstone is composed of pure silica sand with very little lime or other cementing material. The washed product from some beds contains over 99 per cent silica and only 0.001 per cent of iron. It is used chiefly for the manufacture of plate glass. Because of its exceptional purity it was used during the war by the U. S. Bureau of Standards for the manufacture of optical glass.

Quartz

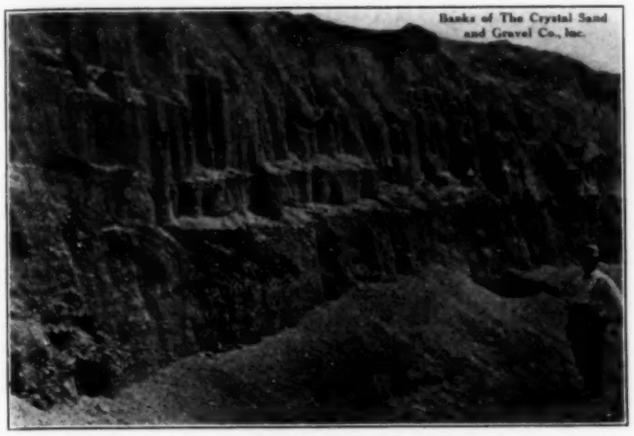
Pure white quartz occurs in large veins at many places in the western parts of the Northern Peninsula. It is quarried and ground near Ishpeming for wood filler, scouring polishes, etc. Analyses show that the quartz rock is practically pure silica.

Clay

There are extensive deposits of surface clays, but most of them are high in lime and are suitable only for the manufacture of common brick and tile. In some of the deposits, leaching has removed the lime to considerable depths. Such deposits are adapted for the manufacture of higher grade products. In Ontonagon county some of the surface clays are of the slip variety and are utilized for glazing purposes. Surface clays are used at many places for the manufacture of common brick and tile. Most of the common brick are produced in the vicinity of Detroit.

Shale

There are relatively few deposits of shale because most of the rock strata are concealed by the cover of glacial material. The only important deposits of shale in the southern part of the State are in Branch, Jackson, Eaton, Ingham, Genesee, Shiawassee and Sanilac



BANKS OF THE CRYSTAL SAND & GRAVEL CO., INC.

counties. There are numerous exposures of shale in Antrim, Charlevoix, Emmet, Cheboygan and Alpena counties, but these are distant from large markets. Shale also occurs in association with coal seams.

Shale is quarried near Coldwater and Union City, Branch county; near Ellsworth, Antrim county, and at Paxton, Alpena county, for use in the manufacture of portland cement, and at Jackson, Jackson county; near Flushing, Genesee county, and at Grand Ledge, Eaton county, for vitrified brick, tile and conduit. Deposits favorably situated in relation to markets and transportation occur at Williamston, Ingham county, and near Corunna, Shiawassee county. Shales associated with the coal beds in Saginaw Valley have been utilized for vitrified brick and tile products.

Sandstone

There are numerous exposures of sandstone in Hillsdale, Calhoun, Jackson, Ionia and Huron counties, in the Southern Peninsula. Most of this sandstone, because of its unstable color, is suitable only for rough building purposes. All of the numerous early quarries are now abandoned.

Unlimited deposits of mottled red and brown sandstone occur along the shores of Lake Superior in the Northern Peninsula. The stone has pleasing and permanent colors, but chiefly because of the great distance from markets the industry has declined until there is but one active quarry.

Petroleum

Petroleum has been struck in small quantities in numerous places in the State, but only at Port Huron has the quantity been sufficient for commercial development. The total output is insignificant.

Natural Gas

A small quantity of gas accompanies the oil produced at Port Huron. In several localities gas is found in small quantities in the glacial drift. The total production of natural gas is unimportant.

Marble

Numerous deposits of *verde antique* marble occur some miles northwest of Ishpeming, Marquette county. Production began in 1918. The marble is composed of serpentine and dolomite, the results of alteration of peridotite rocks. It displays an intricate system of veins and stringers of white dolomite in light to dark-green serpentine. It is massive in character and of excellent quality. The polished product compares very favorably with the best domestic and imported *verde antique*.

Graphite

Graphite occurs in slates in Baraga county. The graphitic slate is quarried and ground for paint material. No attempt has been made to recover the graphite from the slate.

Precious Stones

Chlorastrolite, thompsonite, and some semi-precious stones are produced in small quantities in the copper-bearing region. Chlorastrolite is a beautiful mottled-green gem stone, peculiar to the Lake Superior copper-bearing district. The total value of the annual production of gem stones is very small.

Mineral Paints

Certain of the iron ores in the Northern Peninsula are suitable for the manufacture of paint. Formerly several thousand tons of these ores were produced annually and sold for the manufacture of paint pigment.

Slate

Extensive deposits of slate occur in Baraga county. The slate is very black, of fine texture and permanent in color. It appears to be of superior quality and suitable for roofing and other purposes for which slate is adapted. Prior to 1888 a number of slate quarries were operated for several years near Arvon, Baraga county. Apparently because of inefficient methods of quarrying, great distance from markets and lack of cheap transportation facilities the industry was unprofitable.

Granite

Extensive exposures of granite occur in many localities in the western part of the Northern Peninsula. Several unsuccessful attempts have been made to develop some of the deposits, but no production has been reported for many years.

Pyrite

Pyrite occurs in considerable abundance in some of the coal seams and associated rocks and also at certain horizons of the Antrim black shale. At some of the coal mines, the recovery of lump pyrite offers commercial possibilities. The most promising source of recovery is at the coal washery at Saginaw. Tests show that the refuse contains about 30 per cent of pyrite and that a concentrate containing considerably over 40 per

CRUSHING PLANTS OF THE MICHIGAN ALKALI CO. AT ALPENA

FALLS ON MENOMINEE RIVER ABOVE MANSFIELD

cent of sulphur is possible. Probably the pyritic waste from the different mines would be sufficient to supply a concentration plant.

CELESTITE

Celestite occurs as scattered masses in some of the limestone and glass-sand quarries in Wayne and Monroe counties. At Rockwood, Wayne county, the mineral occurs in masses of sufficient abundance to warrant recovery. No production of celestite, however, has been reported.

FELDSPAR

There are deposits of potash feldspar near Republic in sec. 22, T.47 N., R.29 W., Marquette county, and in sec. 8, T.46 N., R.41 W., Gogebic county. An unsuccessful attempt was made many years ago to develop the deposit near Republic. Probably further investigation in the Northern Peninsula would result in the discovery of other deposits of potash feldspar.

WATER POWER

Water power has been extensively developed on the St. Joseph, Kalamazoo, Grand, Muskegon, Manistee, Thunder Bay, Au Sable and Huron rivers in the Southern Peninsula and on the Menominee, Carp and St. Mary's rivers in the Northern Peninsula. Large powers have been developed on many of the other rivers in the State. There is an abundance of undeveloped water power on these streams, notably the Escanaba, Ontonagon and Taquamenon, and the water powers on the Muskegon, Manistee, Menominee and Au Sable rivers also are susceptible of much greater development.

Salt, Bromine and Calcium Chloride in 1918[1]

The production of salt (in short tons) in the United States during 1918 was as follows:

Grade	United States	Michigan
Manufactured (evaporated)	2,724,203	1,059,872
In brine	2,830,600	.....
Rock salt	1,683,941	.....
Total	7,238,744	2,403,125

Bromine was made as usual from bittern left after extracting salt from the brine pumped from deep wells at Midland and Saginaw in Michigan; at Pomeroy in Ohio; Mason, Hartford and Malden in West Virginia; 1,727,156 lb. of bromine (either as the free element or its salts) was produced in 1918.

Calcium chloride, containing 2 to 6 per cent of magnesium, is recovered as a by-product in the manufacture of salt and bromine in the localities mentioned above. There was produced in 1918 26,624 tons.

[1]U. S. Geological Survey Bulletin, by Ralph W. Stone.

Chemical Industries of Michigan

By W. L. Badger

IN GENERAL, it would seem that in Michigan there is represented practically every important chemical industry, organic and inorganic. In many of the basic industries Michigan is either first or in the first two or three of all the States. Raw materials of all sorts are plentiful, the State is not far from the coal fields, and is almost midway between the great markets of the East and the mid-West. Among the many and various chemical and allied industries the following deserve to be specially mentioned:

SALT

The history of salt manufacture in Michigan goes back to 1838, when the State appropriated $3000 to bore for salt at one of the salt springs. This work was continued for several years, but never gave any results. The first private plant to make salt was at Grand Rapids in 1840, but its life was short. In 1859 the industry was revived, aided by a State bounty; and though the bounty was not continued long, the industry continued to thrive till in 1905 the State led all her sister States in quantity of salt produced, and in 1906 in value of product. This position it has kept ever since. An important feature in the growth of the salt industry was the utilization of waste steam from sawmills. To dispose of waste the sawmills built incinerators; and the next idea was to burn the waste under boilers and use the steam for salt making. Hence we find the largest number of salt companies and the largest total number of grainers in the period from 1880 to 1895. Since then the industry has gradually concentrated into the hands of fewer and fewer companies, which make salt as a primary product and not as a by-product as in the days of the lumber industry.

The most important source of salt in Michigan is the Salina formation of rock salt. In some districts the wells are in higher strata; and in the Saginaw Valley the brine comes from flowing wells. The Salina is, however, the largest and purest deposit. In many cases underground waters flow into the salt beds to yield the brine, but in the majority of cases the brine is artificially formed by pumping water down to the salt layer. Practically all plants in the State work on brines running from 95 to 100 per cent saturated; many never fall more than a few tenths of 1 per cent short of complete saturation. At one of the largest plants in the State, a few years ago the question came up of filtering the water fed to the wells in order to get a cleaner brine. From the records of the amount of salt produced the size of the cavity in the salt bed was estimated; and it was found that if the water spread out evenly over the surface of the cavity, and the brine was drawn evenly from the bottom of the cavity, it would take about three years for the filtered water to appear at the top of the well.

The beds are worked around Detroit and along the St. Clair River. South of Detroit the salt suddenly disappears; and to the north and east the beds rapidly get deeper. Around Detroit the Salina rock salt is at 1000 to 1500 ft. and is 100 to 400 ft. thick. Along the Lake Michigan side the salt reappears, so that the State has three well-marked salt districts—the Detroit district, the Saginaw district and the West district.

Early Processes of Salt Making

Only in the very early days was salt made in the kettle. The next development was the pan—some 20 to 30 ft. wide, 100 to 150 ft. long, and 12 to 18 in. deep. They were direct fired, and the salt was raked out by hand. Little or no salt is now made in this apparatus, though up to a short time ago old salt pans were still standing along the St. Clair River.

With the growth of the lumber industry came the grainer, a distinctly Michigan type of salt-making apparatus. This is a tank 18 to 24 in. deep, 12 to 18 ft. wide and 100 to 120 ft. long. In this are submerged a number of pipes through which passes steam (or hot condensed water from previous grainers). The brine does not boil, but merely evaporates slowly. The size of grain depends on the rate of evaporation, which in turn depends on the temperature of the brine, as the coils are heated by live steam, exhaust steam, or condensed water. The salt grows on the surface as floating aggregates of hopper-shaped crystals. These fall to the bottom and are raked out by hand, or more often by mechanical rakes actuated by hydraulic cylinders. The grainers are made of wood, steel or concrete.

In 1887 the first vacuum pan was introduced into Michigan, and there are now a number of plants using single or multiple effect vacuum pans. This process gives a fine, uniform, compact grain, very well suited for table purposes. The coarse and less compact grainer salt occludes mother-liquor and is less pure.

The Alberger Process of Salt Making

Michigan has the only plant in this country using the Alberger process. In this process the brine is heated in steps to about 350 deg. F., at which point the solubility of calcium sulphate is very low. The brine is then led through cylinders filled with stones, where the gypsum is deposited, the supersaturated solution being seeded by crystals adhering to the stones; and then the brine is led to the "evaporators." These are nothing but cylinders with an opening near the top where the superheated brine is allowed to escape. The flash or self-evaporation which takes place when the pressure is relieved causes the formation of seed crystals. The hot brine with these seed crystals is blown out into large shallow pans. Surface evaporation causes the crystals to grow till they fall to the bottom and are raked to a well, whence they pass to a centrifuge. The brine overflowing from the pans is returned to the heaters. This process gives a very open and porous grain, but far finer than the grainer salt. It is almost entirely used for table and dairy purposes.

No account of the Michigan salt industry is complete without mention of the Manistee Iron Works. They introduced the vacuum pan into the salt industry; and Manistee pans are found not only in most of the vacuum pan plants of the State, but in many salt plants throughout the country.

Table I gives a list of some Michigan salt plants, and Table II gives the Michigan salt production as compared with that of the total in the United States for the years 1914 to 1917.

Bromine and Calcium Chloride

The brines of the Saginaw Valley contain many impurities, chiefly bromides and calcium and magnesium salts. The Dow Chemical Co. of Midland has for years been by far the largest producer of bromine in the United States. The brine is electrolyzed to give a gas consisting of chlorine and bromine, and this gas is used to displace the bromine from the brine. Calcium chloride is made by the Saginaw Chemical Co. Bitterns discarded from salt grainers are further concentrated, which throws out much sodium chloride. The solubility of sodium chloride decreases rapidly as the concentration of calcium chloride increases. The remaining mixture of calcium and magnesium chlorides is concentrated till it solidifies when run into drums. Large quantities of calcium chloride are also obtained as a by-product in the Solvay process.

Alkalis, Acids and Heavy Chemicals

Because of the salt deposits, Michigan has an enormous alkali industry. In the Detroit district are the Solvay Process Co., the Pennsylvania Salt Manufacturing Co. and the Michigan Alakali Co. The Dow Chemical Co. at Midland also produces alkali. The Solvay Process Co. and the Michigan Alakali Co. use the Solvay process; the others make electrolytic caustic. The Pennsylvania Salt Manufacturing Co. uses the Gibbs cell; the Dow Chemical Co. a cell of its own.

Sulphuric and nitric acids are made by the Detroit Chemical Works, which also makes alum. The electrolytic plants of course make either chlorine or bleach according to the demands; though the Dow Chemical

TABLE I—MICHIGAN SALT PLANTS *

Plant	Location	No. Wells	Grainers				Vacuum Pans			Other Processes	Daily Capacity, Bbls.
			No.	Material	How Sifted	Size	No.	Operation	Size		
Bliss & Van Auken Lumber Co.	Saginaw	4	2	Wood	Rakes	170 x10 ft. x 22 in.	...	...	...	...	100
Buckley & Douglas Lumber Co.	Manistee	4	15	Cement	Rakes	150x12 ft. x 22 in.	2	Single	11 ft.	...	2,200
Diamond Crystal Salt Co.	St. Clair	5	6	Steel	Rakes	7 ft. 3 in. x 115 ft. x18 in.	1	Single	6 ft.	Alberger	2,850
Eastman Salt Products Co.	Saginaw	2	4	Wood	Hand	8x110 ft. x 18 in.	...	...	...	...	100
Filer & Sons	Filer City	1	...	...	...	...	1	Single	13 ft.	...	500
Germain, Edward	Saginaw	2	4	Wood	Hand	150x12 ft. x 22 in.	...	...	...	...	...
Hine Lumber Co.	Bay City	1	2	Wood	Hand	150x12 ft. x 18 in.	...	...	...	...	50
Inland-Delray Salt Co.	Delray	2	6	Steel	Rakes	160x16 ft.	3	Triple	9, 10, 11 ft.	...	2,000
Mershon-Eddy-Parker & Co.	Carrollton	3	4	Wood	Hand	145x12 ft. x 18 in.	...	...	...	...	90
Mich. Salt Works	Marine City	2	2	Cement	.....	164x18 ft. x 22 in.	...	...	...	...	.....
			2	Steel	.....	100x18 ft. x 6 ft.	...	...	...	...	.....
			1	Wood	.....	120x12 ft. x 22 in.	...	...	...	...	.....
			3	Cement	.....	120x12 ft. x 22 in.	...	...	...	...	800
Morton Salt Co.	Ludington	5	...	.....	.....	.....	3	Triple	18, 19, 20 ft.	...	2,000
Morton Salt Co.	Pt. Huron	8	9	.....	.....	.....	...	Triple	...	...	3,000
Saginaw Plate Glass Co.	Saginaw	10	14	Cement	Rakes	150x12 ft. x 18 in.	...	...	...	...	1,000
Saginaw Salt Co.	St. Charles	4	10	Wood	Hand	150x12 ft. x 30 in.	...	...	...	...	300
Louis Sands Salt & Lumber Co.	Manistee	4	25	Cement	Rakes	150x12 ft. x 22 in.	...	...	...	...	1,600
Stearns Salt & Lumber Co.	Ludington	3	25	Wood	Rakes	150x12 ft. x 22 in.	1	Single	12 ft.	...	1,400
Peter Van Schaak & Sons	.....	...	...	.....	.....	.....	...	.....	.....	...	.....
Worcester Salt Co.	Ecorse	2	8	Steel	Rakes	140x12 ft. x 22 in.	3	Single, double or triple	10 ft.	...	2,500

* The above data are taken from "The Brine and Salt Deposits of Michigan," C. W. Cook; Mich. State Geological and Biological Survey, Publication 15, Geological Series 12, 1914. The list includes only plants described in the above Bulletin and mentioned as producing in "Mineral Resources of Michigan for 1916," Mich. State Geological and Biological Survey, Publication 24, Geological Series 20.

TABLE II—MICHIGAN SALT PRODUCTION

Year	Total Production of U. S., Bbls.	Michigan Production, per Cent. of Total	Total Michigan Production, Bbls.	Packers						Rock and All Others		Brine	
				Table and Dairy		Common Fine		Common Coarse					
				Bbls.	Value	Bbls.	Value	Bbls.	Value	Bbls.	Value	Bbls.	Value
1914	34,402,772	33.92	11,670,976	1,092,344	$1,025,164	2,668,989	$911,016	2,380,378	$870,715	712,530	$252,024	4,816,735	$240,086
1915	38,231,496	32.93	12,588,788	1,233,117	1,420,382	3,096,644	1,181,337	2,265,353	1,001,167	919,735	321,354	5,073,940	380,491
1916	45,449,382	32.82	14,918,278	1,305,950	1,461,085	3,109,857	1,221,901	2,133,600	1,064,709	1,012,942	368,022	7,365,927	506,850
1917	49,844,121	32.45	16,078,139	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Co. uses most of its chlorine in various organic products.

The North American Chemical Co. at Saginaw makes electrolytic chlorate.

Potash

Michigan's contribution to the potash situation has been from two sources—wood ashes and beet sugar waste waters. This latter is mentioned in connection with the sugar industry. In the hardwood districts there are reported about 25 small producers of potash salts from wood ashes. The ashes are packed in shallow tubs, leached, and the resulting solution concentrated till it solidifies. The product is mainly carbonate; if lime is added with the ashes it is largely hydroxide. Of some 32,500 tons of K_2O reported as produced in the United States in 1917, wood ashes (in which Michigan has 25 out of 49 producers) are credited with furnishing 621 tons, and beet sugar waste waters (where Michigan has one out of 5 producers) with 370 tons.

Iron and Steel

Though Michigan is the second largest producer of iron ore in the United States, the iron actually smelted is very small in amount. The Marquette, Gogebic and Menominee ranges, lying mainly in Michigan, produce about 25 per cent of the country's total output of ore and about 30 per cent of the output of the Superior district. Michigan is only about seventh in pig iron production, having only 14 blast-furnaces. The State has no steel plants, though there are steel foundries having one or two open-hearth furnaces apiece. Most of the blast-furnaces are connected with the hardwood distillation industry, and serve as an outlet for the charcoal. Detroit has three furnaces—two at the plant of the Detroit Iron and Steel Co. and one at the plant of the Detroit Furnace Co.

Table III gives a list of the Michigan blast-furnaces operating in 1916.

TABLE III—BLAST-FURNACES OPERATING IN 1916.

Lake Superior Iron & Chemical Co.	1	Boyne City
Lake Superior Iron & Chemical Co.	1	Chocolay
Mitchell-Lignite Iron Co.	1	Cadillac
Detroit Furnace Co.	1	Detroit
Detroit Iron & Steel Co.	2	Detroit
East Jordan Furnace Co.	1	East Jordan
Cleveland Cliffs Iron Co.	1	Gladstone
Antrim Iron Co.	1	Antrim
Pioneer Iron Co.	2	Near Marquette
Stephenson Charcoal Iron Co.	1	Wells
Charcoal Iron Co. of America	1	Chocolay
Charcoal Iron Co. of America	1	Boyne City
Charcoal Iron Co. of America	1	Elk Rapids
Charcoal Iron Co. of America	1	Manistique
Charcoal Iron Co. of America	1	Newberry
New Metals Process Co.	1	Marquette

Non-Ferrous Metals

Michigan has for some time been the country's third largest producer of copper. Other than this no non-ferrous metals are smelted in appreciable amounts. The State has some of the largest copper and brass mills in the country, including the Detroit Copper & Brass Rolling Mills, the Michigan Smelting & Refining Co., the Michigan Copper & Brass Rolling Mills.

Coke

The State possesses two coke oven plants, neither primarily connected with the iron industry. The ovens are at the plants of the Solvay Process Co. and the Michigan Alkali Co.; and both plants use the ovens as a source of ammonia. The coke goes to the blast-furnaces in Detroit, to the lime kilns of the alkali process, or is sold for domestic consumption.

The Solvay Process Co. obtains its ammonia from the Semet-Solvay Co., which operates 175 Semet-Solvay ovens. The latest bank of these are equipped to burn producer gas, as under a heating value specification so much gas can be sold to the city of Detroit that not enough remains to heat the ovens. All the newer ovens are regenerative, in contrast with the older design of the Semet-Solvay oven, which was recuperative.

The Michigan Alkali Co. has 30 United-Otto ovens.

Coal and Peat

A large area in the central part of the State contains coal. The deposits have been worked more or less since 1835, but the industry did not develop till 1897. Recently the production has been about 1,000,000 tons per year. The coal is bituminous, dry and non-coking, and generally of a lower grade than the Eastern coals with which it has to compete. In 1916 there were reported 22 mines.

The State has very extensive deposits of peat—in fact, over the whole State peat bogs are common. Numerous attempts have been made to work these deposits, and much good money has been wasted. Without exception the plants have all been failures. The peat remains, however, as a possible fuel when either coal is so high as to make it available, or satisfactory methods are found for its utilization.

Beet Sugar

Michigan is almost the home of the beet sugar industry in the United States. Certainly the industry took hold here in a very healthy manner and mills were built more rapidly in Michigan than in any other State. As the value of irrigated lands and the favorable climate of the Western States began to be appreciated, Colorado and California passed Michigan, but Michigan still remains one of the principal producers of beet sugar. Table IV is taken from the U. S. Department of Agriculture Yearbook, 1917.

The drop from third to fourth place in 1916 was due not only to the falling off in the Michigan production, but to the rapid rise of Utah as a beet sugar State.

The beet mills in the State are shown in Table V.

TABLE IV—BEET SUGAR INDUSTRY IN MICHIGAN

Year	Michigan's Rank	No. Factories	Campaign Days	Tons Sugar Made	Acres Harvested	Tons Beets per Acre	Tons Beets Worked	Price per Ton	Per Cent Sugar in Beets	Purity	Per Cent Sugar Recorded	Per Cent of Total Sugar Recovered	Per Cent Loss	Michigan Production per Cent of U. S. Total
1914	3	15	68	110,630	101,300	8.5	857,100	$5.23	15.78	82.85	12.91	81.81	2.87	15.3
1915	3	15	78	129,997	122,000	8.2	997,972	5.91	15.45	84.08	13.03	84.34	2.42	14.7
1916	4	15	49	69,341	99,619	5.05	502,705	6.14	16.37	85.22	13.79	84.24	2.58	8.4
1917	4	14	53	64,247	82,151	5.62	461,721	8.04	16.28	86.57	13.91	85.44	2.37	8.4

The figures are from the Department of Agriculture Bulletin No. 721.

TABLE V—BEET SUGAR PLANTS IN MICHIGAN

Company	Location	Erected	Tons Beets Worked in 24 Hours
Holland-St. Louis Sugar Co.	Holland	1899	500
Michigan Sugar Co.	Bay City	1899	1,400
Michigan Sugar Co.	Alma	1899	1,400
West Bay City Sugar Co.	West Bay City	1899	900
Michigan Sugar Co.	Caro	1899	1,200
Independent Sugar Co.	Marine City	1900	600
Columbia Sugar Co.	West Bay City	1901	1,500
Owosso Sugar Co.	Lansing	1901	600
Michigan Sugar Co.	Carrollton	1902	900
Mount Clemens Sugar Co.	Mount Clemens	1902	600
Michigan Sugar Co.	Croswell	1902	750
Michigan Sugar Co.	Sebewaing	1902	850
Holland-St. Louis Sugar Co.	St. Louis	1903	600
Menominee River Sugar Co.	Menominee	1903	1,200
Owosso Sugar Co.	Owosso	1903	1,200
Continental Sugar Co.	Blissfield	1905	868

This shows the State to have a total capacity of 15,000 tons of beets per day. With a campaign of 70 days this calls for a little over 1,000,000 tons of beets for the campaign. This means that the industry was working to capacity in 1915; but, with a campaign of 50 days, only about two-thirds capacity in 1916 and 1917.

Many mills run the Steffens process, and many dry their pulp for the manufacture of cattle feed. Since the mills are all older than most Western mills, the newer equipment (such as labor-saving filters, etc.) found so frequently in the Western mills has not yet been generally introduced.

Two interesting developments in connection with the sugar industry are the plants of the Michigan Chemical Co., at Bay City, which ferments beet molasses to alcohol; and the plant of the Columbia Sugar Co. which has been evaporating its Steffens waste water for the recovery of potash.

Wood Distillation

Michigan ranks in the first two or three States in the quantity of wood distilled. This is largely centered in the Upper Peninsula, though there are some wood distillation plants in the Lower Peninsula. E. I. du Pont de Nemours & Co. has plants at Bay City and Brayling. The Cleveland-Cliffs Iron Co., the Charcoal Iron Co. of America and the Lake Superior Iron & Chemical Co. all operate plants in the Upper Peninsula for the distillation of wood. Michigan plants produce finished acetone, wood alcohol and gray acetate of lime. In connection with many of the plants are also charcoal blast-furnaces.

Paper

Michigan is a very important paper State. The district around Kalamazoo and from there west to Lake Michigan is the most important book paper district in the country. At one place or another in the State nearly every kind of paper is made, but the principal output is book paper.

There is no mill in the State making soda pulp. Sulphite pulp is made by both the slow and the quick cook process. The reworking of old paper is a very important feature of most of the mills. There are boxboard and strawboard mills, one concern makes parchment papers of all sorts, and another makes a specialty of unusual finishes and colors for covers, photograph mounts, etc. There are 30 to 35 paper mills in the State.

One interesting feature of the paper industry is that it is the second industry in the State to unite in maintaining co-operative research. The Michigan Gas Association has for many years maintained a research laboratory and fellowship funds at the University of Michigan, and in 1915 a group of paper manufacturers united to found such an arrangement for the paper industry. The war has greatly interfered with the plans, as might be expected, so that not nearly as much has been accomplished as in the same length of time had conditions been normal.

Dyes and Organic Chemicals

The State has two dye plants—the Holland Aniline Co. and the Dow Chemical Co. The Holland Aniline Co. confines itself to a few dyes, including methyl violet, sulphur browns and blues, and bismark brown. The Dow Chemical Co. has long been a producer of chloroform, the manufacture of which was indicated by its production of chlorine in connection with the bromine process. From this, at the beginning of the war, it was only a step to other simple organic chemicals, then the more complex ones, and finally dyes.

Paints and Varnishes

The State contains two of the largest paint and varnish plants, together with a number of smaller ones. The Acme White Lead & Color Works and Berry Bros., both of Detroit, are among the most important plants in the country in their respective lines. There are also the Boydell Bros. White Lead & Color Co., the Detroit Graphite Co., the Detroit White Lead Works and the International Color & Chemical Co.

Tanning and Tanning Materials

There is a large number of tanneries all over the State. All kinds of leathers are made—sole leathers, belting, harness, as well as uppers and fine leathers. Chrome, oak, hemlock and tropical extracts are used.

The Michigan Tanning & Extract Co. operates a number of plants, mainly in the Upper Peninsula, for the manufacture of tanning extracts from hemlock bark. The bark is leached in open tanks, and the extract concentrated in multiple effect evaporators.

Other Organic Industries

The U. S. Rubber Co. has a plant in Detroit—the Morgan & Wright plant—making rubber tires of every description. The manufacture of pharmaceutical products is represented by Parke, Davis & Co., the Fred-

erick Stearns Co. and the Digestive Ferments Co., all of Detroit.

The Franck Chicory Co. has several plants through the State for the manufacture of chicory products. The famous plants at Battle Creek making all sorts of special and standard food products must be remembered. There are several plants for the making of condensed milk; and in the southwest part of the State is an important grape district in which are grape-juice plants. And in this connection it is possibly appropriate to mention the Detroit Reduction Co., which takes Detroit's garbage and converts it into fertilizer and grease by the ordinary process of digesting with steam under pressure.

Ceramic Products

Michigan has plenty of clays, but has little in the way of ceramic industries except the manufacture of common brick. There are a few tile plants, but as a general thing the clay-working industries are confined to ordinary building brick.

Cement and Building Materials

The manufacture of portland cement in Michigan was begun in 1896. In 1901 the State made 1,000,000 bbl., and was the third largest producer in the country. In the last ten years its rank has been fifth to eighth, and it has made from 4 to 5 per cent of the total output of the whole country. Owing to the fact that the important limestone deposits are in the northern part of the State and relatively inaccessible, most of the plants use marl. One plant successfully used the residue of calcium carbonate obtained in making NaOH from Na_2CO_3. This is the Wyandotte Portland Cement Co., operating on the waste from the Michigan Alkali Co. In all, there are 11 active plants making portland cement in Michigan. Table VI gives the Michigan cement production for the years 1913 to 1917 as compared with that of the total in the United States.

TABLE VI—MICHIGAN CEMENT INDUSTRY

Year	No. Mills	State's Rank	No. Kilns	Daily Capacity Bbl.	Total U. S. Production Bbl.	Michigan's Production, Bbl.	Michigan's per Cent of U. S. Total
1913	11	8	83	19,900	92,097,131	4,186,236	4.21
1914	11	7	77	19,100	88,230,170	4,285,345	4.85
1915	11	5	71	20,800	85,914,907	4,765,294	5.55
1916	11	7	68	20,650	91,521,198	4,919,023	5.37
1917	11	7	..	.....	92,814,202	4,688,899	5.06

Gypsum is always present in salt beds, and is the principal source of trouble in salt making. As one superintendent put it, "When the Lord made salt beds He put some gypsum in so that the salt maker wouldn't have too easy a time." And the small amounts of gypsum that form on the tubes and pipes in salt plants probably represent more time and money than all the gypsum produced as a primary product. However, Michigan has deposits of gypsum that are worked for gypsum as such. Eight plants handle this material, making land plaster, plaster of paris and special forms such as blocks, tile, etc. In the last ten years Michigan has been in third or fourth place in this country in quantity and value of gypsum products produced. Table VII gives the Michigan gypsum production for the years 1913 to 1917 as compared with that of the total in the United States.

TABLE VII—MICHIGAN GYPSUM INDUSTRY

Year	Ground to Land Plaster, Tons	Calcined, Tons	Sold as Crude, Tons	Total Production, Tons	Total U. S. Production, Tons	Mich. Rank	Mich. per Cent of U. S. Total
1913	9,604	278,368	60,706	423,896	2,599,508	3	16.3
1914	9,322	249,648	61,227	393,006	2,476,465	3	15.9
1915	9,799	245,484	69,572	389,791	2,447,611	3	16.0
1916	9,072	292,109	80,298	457,375	2,757,730	3	16.6
1917	7,090	257,588	61,065	375,803	2,696,226	3	13.9

The State has many deposits of limestone that are worked; varying all the way from extremely high calcium material to dolomites. The sugar industry of the State is almost entirely supplied with high calcium limestone from the northern part of the Lower Peninsula. The Solvay Process Co. gets its limestone from Sibley, a few miles below Detroit, while the Michigan Alkali Co. brings its limestone from Alpena.

In spite of its many deposits of brick clays, Michigan has been the first State in production of sand-lime brick since the process was introduced in this country. Michigan produced 26 per cent of the total for the United States in 1917. There are ten or twelve plants in the State, making building brick almost exclusively.

During the war, when every effort was being made to get optical glass with the maximum transmission, so that when made into periscopes and range finders the range of vision might be as great as possible, the principal problem seemed to be to keep minute traces of iron out of the glass. In their search for iron-free raw materials, the glass people finally came to Michigan for their sand. The American Silica Co., operating a deposit near Detroit, was able to furnish a purer sand than any other deposit in the country.

Conclusion

The enormous growth of the automobile industry has stimulated every form of metal working and fabricating industries; which means that there is a corresponding demand for the products of the various chemical and semi-chemical processes. For of the chemical and related industries it is especially true that they produce supplies for other industries; in few cases do they make articles which go directly to the ultimate consumer.

With the chemical industries resting on the sure basis furnished by the salt and alkali industries, and the markets assured by the enormous general manufacturing interests of the State, there seems to be a very bright future for Michigan as a great technical State.

An American Chamber of Commerce for Havana

A plan is apparently assured to form an American chamber of commerce at Havana similar to organizations of this kind at Paris, London and several other cities.

It is intended to have the work of the organization extend to all parts of the island and to make it a factor of much value in American trade. It is believed that the organization can be of service in matters of transportation, prompt passage of merchandise through the customs, credits, advertising, etc.

The American Minister has been active in bringing about the new organization, in the interests of which the first meeting was held at the American Legation and attended by more than 100 American citizens. At this meeting, held on July 15, 1919, a temporary organization was effected, and at an early date it is expected to complete the organization and secure suitable quarters and a permanent secretary and such other assistants as may be required. The consulate general is taking an active part in the new project and will be able to render much assistance to it.

Natural and Industrial Resources of Wisconsin

A Description of Some of the Mineral Resources and a Review of Some of the Chemical Industries—Present Status of the State's Zinc Industry and Prospects for Future Development

Raw Material Resources of Wisconsin

By W. O. Hotchkiss
State Geologist

WISCONSIN is very close to an average State in almost all particulars. The average State should have a standing of about 2 per cent, and since there are 48 States Wisconsin has more than her 2 per cent of wealth and population and almost exactly 2 per cent of the area of the United States. In raw mineral reserve products, however, Wisconsin has only about half of the average of the country, its total mineral production being about 1 per cent of that of the United States. Of the important mineral resources, Wisconsin produces no coal, no copper and no precious metals, so barring these from the list of products of the country Wisconsin has considerably more than the average State in production of raw mineral materials.

Zinc Ores

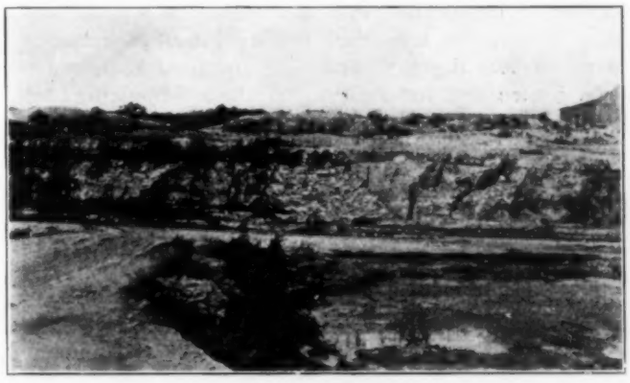
The principal mineral resources of Wisconsin are zinc, iron and stone. Before the World War zinc ore and iron ore were approximately equal in value, but owing to the great demand for zinc during the war the production of that metal increased nearly four times in value, so that in 1918 the zinc ore produced in this State was worth over $5,000,000. In 1916 and 1917 the value each year was between $7,000,000 and $8,000,000. The metal content of the ore was worth approximately double the value of the raw material. On account of this great development in the zinc industry it is now the largest single item in value of the mineral production of the State. Zinc mines are located

WINDSOR MINE

in the southwestern portion of the State and the district overlaps a little into the adjacent States of Iowa and Illinois.

On the average, the zinc mines are less than 200 ft. in depth, and as the ore comes from the mine it contains considerable limestone, and iron sulphide in the form of marcasite. The limestone is eliminated by concentration, and the marcasite and zinc sulphide are then sent to a roaster in which the marcasite is given a magnetizing roast and separated from the zinc sulphide in a magnetic separator. During the war plans were made for installing contact acid plants to use the gas from some of the largest roasters. Some of the mines have their own roasters, but many of them ship their ore to central plants, where the marcasite is removed from the zinc sulphide.

The principal production of zinc is from the mines of strong companies. The Mineral Point Zinc Co., a subsidiary of the New Jersey Zinc Co.; the Wisconsin Zinc Co., a subsidiary of the American Zinc Roasting



GRANITE QUARRY AT BERLIN

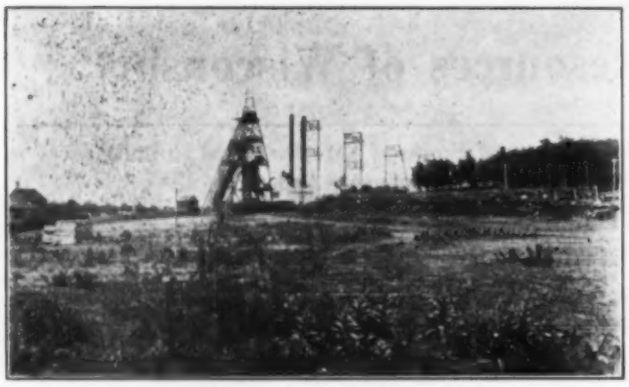
& Smelting Co.; the Vinegar Hill Zinc Co.; the Frontier Mining Co.; and the Field Mining & Milling Co. produce approximately three-quarters of the total zinc production. Each of these companies operates several mines.

The crude ore before milling varies greatly in zinc content. Some mines will produce as little as 5 per cent of concentrates from the ore and others will produce more than 20 per cent of concentrates. In some cases, while running on especially rich ore bodies, a much higher percentage of concentrates is recovered. The ore going to the mill is much richer than the Joplin ore.

In the northern portion of the district, in the vicinity of Highland and Mineral Point, some portions of the ore bodies have been altered to zinc carbonate. This finds a ready market at the zinc oxide works of the Mineral Point Zinc Co. at Mineral Point, Wis., which is one of the largest zinc oxide plants in the United States and draws its ore supplies not only from this district but from the far West and Southwest, and even from Mexico.

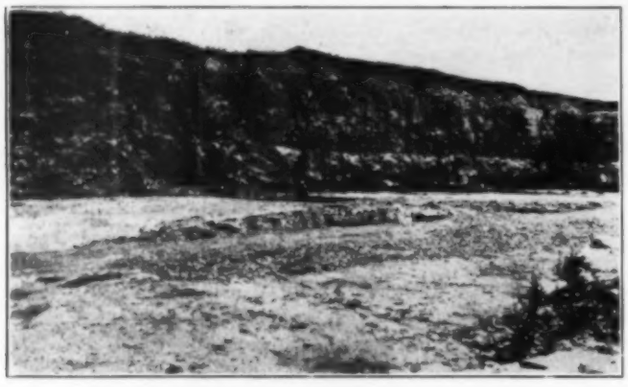
Iron Ores

The iron ore of Wisconsin is produced at present from four districts. The largest tonnage comes from the Gogebic Range, which lies in the extreme northern part of the State and extends over into Michigan, where



MONTREAL HEAD FRAME

the main production of the Range is secured. In the northeastern corner of the State, in Florence county, there is a small production, and in the Baraboo Range, in the south central part of the State, there is one operating mine. All of these ores are Huronian and of the usual Lake Superior type. In Dodge county, about 50 miles northwest of Milwaukee, there are Ordovician ores similar to those in Birmingham. These are of a much lower grade than the Lake Superior type of ore. Large reserves of low-grade ore have been thoroughly proved in this district, and also in the Baraboo district. There are in addition to these producing districts a number of districts in the State which offer great promise for the production of iron ore when



BRILLION LIMESTONE QUARRY

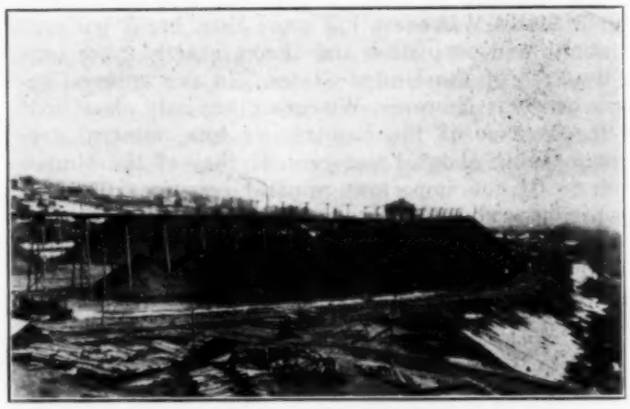
concentration of low-grade material is undertaken. In the western end of the Gogebic Range and in the Black River Falls district there are literally hundreds of millions of tons of magnetic formation that will doubtless be concentrated before many years.

Possible Undiscovered Iron Ranges

In the northern half of the State there are great areas in which the glacial drift entirely obscures the rocks but in which there are doubtless to be discovered important iron ranges. The State Geological Survey has been carrying on for the last eight years a comprehensive program of geological and magnetic study of this portion of the State for the purpose of discovering all areas in which exploration appears to be warranted. Exploration which has followed upon published reports has proved the existence of Huronian rocks such as are associated with the Lake Superior iron ores, so that definite proof has been secured that there are first-rate opportunities for the discovery of new iron ranges. Only a small fraction of the total area to be examined has as yet been covered.

While Wisconsin is not in a class with Minnesota as an iron ore producer, it ranks fifth among all the States, and its annual production, if loaded upon the largest size of ore cars, would make a continuous train from the State line north of Chicago to Milwaukee, and from Milwaukee clear across the State to La Crosse. With its large reserve of low-grade ore, and the opportunities for the discovery of other Lake Superior iron ranges in the little known northern portion of the State, Wisconsin promises to stand high as an iron ore producer for many years.

Widely distributed over the glaciated northern portion of the State are marshes which contain bog ore. This ore is usually in comparatively shallow deposits



ROCK PILE NEAR NO. 4 SHAFT, MONTREAL MINE

of a few inches to a few feet in depth, but its character is such that it may in the future have a large value for special purposes.

Stone Production

The third in rank of Wisconsin's mineral resources is its stone production. If under stone one included similiar products and the derived products, such as lime, sand and gravel, Wisconsin's stone production would be worth more than its iron ore. In these days of concrete construction and extreme activity in highway building Wisconsin is fortunate in having widely distributed over four-fifths of the State excellent glacial sand and gravels; and over the unglaciated portion, and in a considerable part of the glaciated portion as well, abundant local supplies of limestone, trap rock and granite, which make the best of materials for highway and structural purposes. In 1917 Wisconsin produced over $1,000,000

STURGEON BAY STONE QUARRY

worth of lime. Nearly $870,000 worth of this was used for building purposes, about $90,000 worth was used in the manufacture of paper, and large amounts were supplied to blast-furnaces for flux, to chemical works, to tanneries, and to glass factories, and there is a small but rapidly growing use of this material as a fertilizer for sour soils. Limestone was produced in the State to a total value of nearly $1,200,000 in 1917. Nearly three-quarters of this value was represented by crushed stone used for road making and for concrete construction. The largest other item was flux for blast-furnaces, with almost equal values for the production of rubble and riprap stone. Rough and dressed building stone was produced in minor amounts, and small amounts of limestone were used for paper mills and agricultural purposes.

LIMESTONE QUARRY NEAR WAUKESHA

The State's Granite Resources

Wisconsin possesses important resources in granite, some of the finest monumental stone in the world and the hardest and most durable granites being quarried in the State. The total production in 1917 was valued at $1,250,000. Of this total minor values were represented in rough stone, rubble, riprap and crushed stone amounting to somewhat over $150,000. The remainder, about $1,100,000, was almost evenly divided in value between dressed and monumental stone and paving blocks. Wisconsin paving blocks are used in all the principal cities in the northern Mississippi Valley, as far south as St. Louis and as far east as Cleveland.

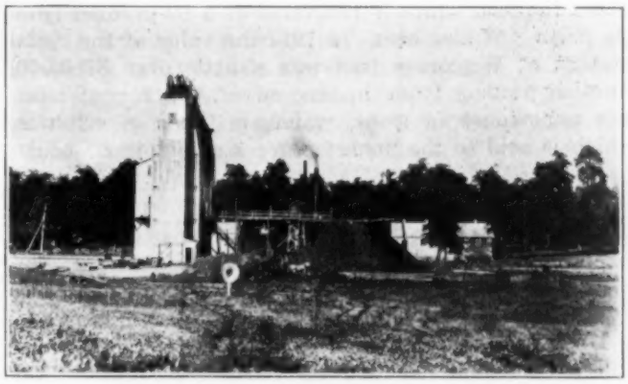
In 1917 Wisconsin produced nearly $300,000 worth of sandstone and ganister. Over half of this value was quartzite used for the manufacture of refractory brick and produced in the vicinity of Baraboo. This quartzite is very pure silica, seldom containing as much as 1 per cent of impurities, and its pure and refractory character make it especially valuable for bricks for furnace linings. Some of Wisconsin's sandstones make excellent building stone of a beautiful, soft light buff color. When the war cut off the supply of foreign material, stone from Wisconsin's sandstone quarries was selected to be used for finishing a cathedral in New York City.

Wisconsin gravel is widely distributed over the State and is used in vast quantities for road construction. Nearly $500,000 worth was used for this purpose in 1917, which represented nearly 1,500,000 tons. Nearly 500,000 tons, valued at $67,000, were used for railroad ballast. Considerable quantities of sand were used for molding sand and paving sand, and nearly 300,000 tons were used for building sand. The total value of sand and gravel production in 1917 was nearly $1,100,000.

If the production of limestone, lime, granite, sandstone, and sand and gravel be included under the general head of stone industry, Wisconsin's production in 1917 was valued at approximately $4,800,000. These figures are for value at the quarry or pit and do not include any transportation charge. If transportation to the consumer were included as a part of this industry, the stone industry in Wisconsin could be said to bring in nearly $15,000,000 a year to its citizens.

Other Raw Materials

Mineral waters of Wisconsin are world famous. In former days when the discreet citizen decided that he had enough of stronger fluids he was very likely to ask the bartender to fill his glass with a world-famous brand of Wisconsin mineral water. Wisconsin mineral waters are shipped all over the world, and in both quantity and value Wisconsin leads all other States in the Union. In 1917 the total production at the spring was valued at $1,362,000, an average price per gallon of 22c. This was less than the usual production because of the stoppage of world trade by the war. The main production of Wisconsin's mineral waters comes from the city of Waukesha. The clay products of Wisconsin include chiefly brick and tile, and the value of the production in 1917 was $1,114,000. The glacial clays of Wisconsin are very abundant, and there are small local brick plants, with a few large plants, which supply considerable areas. These clays are not suitable for fire brick or paving brick, but a good quality of front brick is made in some of the yards.



MAYVILLE SHAFT, NORTHWESTERN IRON CO.

NO. 4 HEAD FRAME, MONTREAL MINE

CARY MINE AND STOCK PILES

Next in order of Wisconsin's mineral production comes the lead which is recovered as a by-product from the milling of zinc ores. In 1917 the value of the metal content of Wisconsin lead was a little over $700,000. Another product from the zinc mines, which is of much less importance in money value, is the iron sulphide, which is sold to the manufacturers of sulphuric acid.

There are deposits of carbonaceous schists in Wisconsin, in which the carbon has been very much altered so that it is clearly graphitic. One of these deposits has been used for the manufacture of a very good grade of graphite paint.

Large Areas of Peat Bog

An undeveloped mineral resource of Wisconsin which bids fair to be of great importance in the future for a wide variety of purposes is found in its great areas of peat bog. The State Geological Survey examined peat bogs of a total area of 121,000 acres, in which it was estimated that there is available at least 150,000,000 tons of air dried peat. It was further estimated that there are over ten times as many deposits as were examined, and a general estimate is given that there are between 2 and 3 billion tons of dried peat available in Wisconsin. Much of this will doubtless be drained and used for agricultural purposes, for which it makes very valuable soil, but as the chemical industry in this country increases chemists are bound to find more valuable uses for large quantities of this material.

Chemical Industries of Wisconsin

By O. L. Kowalke

A WIDE variety of chemical industries is represented in Wisconsin, but among these the leather and paper industries are the most important on the bases of value of product and number of men employed.

The leather industry of Wisconsin ranks fourth among all the industries of the State and third in the leather industry of the United States. The employees constitute 10.5 per cent and the value of the products, $42,200,000, constitutes 11.5 per cent of the total for the country in 1914. Milwaukee is the second city in the country on the bases of size of tanneries and the value of the products. The principal product is "calfskin upper," 2,292,800 sides, of which more is made here than in any other State; sole leather, with 1,122,200 sides, comes next in order, and is followed by harness leather, with 631,787 sides. Of the latter more is made in Wisconsin than in any State in the Union.

Wisconsin is one of the leading pulp and paper producing States in the country, being surpassed in the consumption of wood for this purpose only by Maine and New York in the order named. There are 30 ground wood, 20 sulphite and 5 sulphate pulp mills in the State, which in 1917 produced about 400,000 tons of pulp, consisting of 45 per cent unbleached sulphite, 38 per cent mechanical, 8 per cent sulphate and 9 per cent bleached sulphite. Besides the wood pulp paper, such as news, writing, book, tissue, wrapping, etc., considerable amounts of rag paper and container board are made, amounting in all to 480,851 tons in 1917. A number of specialties were developed in Wisconsin for war purposes, such as cellu-cotton, a wood pulp substitute for absorbent cotton; special waterproof containers for packing and shipping shells and other war supplies, and the use of waste hemlock bark, produced from the rossing of wood, for the manufacture of hemlock extract. Other specialties, not for war purposes, are fiber rugs, filter mass (the plant being the largest in the United States), and molded pulp products.

There are several chemical industries that rank well to the front in the country. Of these the rubber industry ranks sixth in the value of products, $7,382,108, for five establishments in 1914, the principal product being automobile tires. The 11 soap factories, with an output valued at $2,894,000, rank tenth in the country in this industry on the bases of persons employed and value of the products. The increase in value of the finished products over the raw materials is 117 per cent. In this respect Wisconsin is led by only one State, which gives a measure of the high grade of soap made. Gas for domestic and municipal consumption made in 47 plants is valued at $5,294,000, which puts the group in tenth place in the industry. Not included in the group of 47 gas plants are two by-product coke-oven plants, in one of which 250 ovens are in operation, producing 1800 tons of coke daily.

The census of 1914 ranks Wisconsin nineteenth in a group called chemical industries, comprising 395 establishments engaged in the manufacture of acids, sodas, alums, coal-tar products, cyanides, bleaching materials, chemicals by electrolysis, plastics, compressed and liquefied gases, and other chemicals. Most of these materials are made here. Sulphuric acid is made in two plants, one using the contact process; nitric acid is made in one plant; three plants are engaged in making bicarbonate and sal soda. The compressed and liquefied gas industry has kept pace with the growth of the foundry and machine tool industry; two plants make compressed acetylene; two make compressed oxygen and hydrogen, while at one plant of considerable size compressed oxygen is obtained from the air.

Miscellaneous Other Industries

Another group of industries not included in the above list but of equal importance is worthy of consideration. Of major importance in this group are four beet sugar factories having a combined daily capacity of 2800 tons of beets; one glue factory capable of handling all the wastes from the Wisconsin tanneries in addition to large amounts of raw materials shipped in from other sources; and a match factory of large capacity. The dry battery industry ranks third in its group and is

output is about 2 per cent of the total in the country. In the manufacture of dynamite and permissible explosives, Wisconsin ranks sixth among the seven States producing nine-tenths of these commodities. Other industries on which statistics are not available include the following:

Industry	Number of Establishments	Industry	Number of Establishments
Lime	30	Wood alcohol and acetate of lime	3
Fertilizers	8	Glycerine	2
Paints ready to use	6	Insecticides	2
Iron buff and other colors	3	Baking powder	2
Zinc oxide	1	Electroplating	10
Varnish	1	Glass bottles	1

A number of industries were established as a result of the war. Among these is the production of potash from wood ashes. In 1917 21 plants were in operation in Wisconsin and 25 in Michigan, which together produced 1035 short tons of crude potash, or 2 per cent of the total potassium oxide production in the United States. The initial cost of the average sized potash plant, including the building, was between $3000 and $4000.

The production of high explosives in Wisconsin in 1916 amounted to 6,515,032 lb., which was 2½ per cent of the total manufactured in this country. Closely associated with the production of high explosives is the manufacture of coal-tar dyes and dye intermediates in one large plant. This plant made a number of intermediates in large quantity and is now well established for peace-time production.

Laboratory of Chemical Engineering,
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Zinc in Wisconsin

By A. M. Plumb

PROBABLY the history of few mining districts could be as definitely divided into two epochs as that of the Wisconsin zinc mining district. From the advent of the whites into the section in the last quarter of the seventeenth century up to the end of the nineteenth century, the district was practically a lead district. The history of the pioneer lead miners and smelters up to the beginning of the twentieth century has been fully covered by numerous writers, and in most cases these histories are closed with the nineteenth century, which marks practically the beginning of the zinc industry, and simultaneously the ending, to all intents and purposes, of the lead industry.

There is, of course, an important lap of these epochs in the case of the Mineral Point Zinc Co. At Mineral Point numerous efforts have been made to produce zinc metal and zinc oxide, which have all been described, from which has evolved the present Mineral Point Zinc Co., which has discontinued any attempts to produce metal, but has been successfully producing oxide by the old Wetherill process for many years, ores being derived from numerous distant points, even as far south as New Mexico, and as far west as Nevada.

Production of Zinc From Mixed Sulphide Ores

At the beginning of the present century, the possibility of producing zinc from the mixed sulphide ores attracted the attention of miners and metallurgists from many different mining sections of the country. The presence of pyrite and marcasite was so general as to make the direct production of smelting concentrates out of the question, except in rare, isolated cases. In the early '90s an effort was made to effect a separation of the zinc blende and marcasite by a secondary treatment. Prof. R. P. Blake, who had some advance information on the physical properties of the Wisconsin marcasite, attempted to separate these products by a preliminary roast followed by a wet jigging operation. On account of the fact that the marcasite particles when roasted are affected in a manner very similar to the effect upon popcorn when subjected to heat, hydraulic diameters of these are materially changed. Particles after roasting will be found to have numerous fissures extending toward the center of the particle, and, in addition to the fissures, the whole mass is left in the form of a sponge. While it is probably a fact that this particle will have slightly less specific gravity than the blende particle, its shape and structure is such that it will be found to ride considerably higher on a jig bed than will the zinc.

This attempt resulted in some surprisingly high grade finished product, but the loss of zinc in tailings was so great as to render the process of practically no economic value. This excessive loss was almost entirely a loss of fines. While the resultant product of a jigging separation in Wisconsin is considered coarse, i. e., all through a ⅜-in. screen, the roasting operation produces a considerable amount of extreme fines on account of decrepitation, and most of this in the process above described will be lost.

Ores Separated Magnetically

Early in 1900 some experiments were made which resulted in the present successful separation of these ores, which is accomplished by a preliminary roasting and subsequent magnetic separation. The first commercial attempt along this line can easily be considered a complete success. The operation consisted in passing the ore through a revolving type of furnace similar to a Howell-White, but having a dam at both the feed and discharge ends to retain a quantity of ore in the cylinder so that the passage through the apparatus was retarded. The roasted product is then passed to almost any of the types of magnetic separator, resulting in a surprisingly complete separation.

This process was considered a part of the standard equipment in the Wisconsin field until the year 1915, when the Wedge type multiple hearth roaster was introduced, with great success, after the minor initial difficulties had been surmounted. The savings, however, over the older process have been practically negligible aside from the dust loss. In the old type of furnace the dust loss was substantially 5 per cent, whereas in the new type it is about 1 per cent. The separations effected are practically identical.

I have mentioned that the simultaneous occurrence of marcasite and zinc blende was the great problem in the beginning of this industry. It is then somewhat surprising to discover the extreme kindness of nature when the process is finally evolved, in that a very large percentage of the objectionable gangue materials is found to be associated with the marcasite. As an example, out of an ore running 39.6 per cent Zn, 15 per cent Fe and 2.9 per cent CaO, the magnetic material discarded as tailings runs 4.8 per cent Zn, 48.5 per cent Fe, 4.9 per cent CaO and 3.35 per cent ZnS. The finished product, containing 95 per cent of the zinc contents of the feed, runs 61.5 per cent Zn, 1.6 per cent Fe and 2 per cent CaO.

This result is accomplished by following somewhat different lines than would ordinarily be attempted. It is the first thought of most metallurgists when difficulties in separation arise to crush to a smaller size. In Wisconsin this turns out to be a mistake, since any additional crushing will liberate some of the lime and insoluble which are components of the marcasite particles, so that finally the separation in Wisconsin is accomplished with best results at as coarse size as the mill product can be produced.

On the other hand, there are some natural properties which if not guarded against will lead to economic loss. The marcasite particle after roasting is made up of a combination of a so-called artificial pyrrhotite and amorphous iron oxide. This latter forms the outside surface and is so soft as to be easily crushed between the thumb and finger. It is then necessary to subject this product to the least amount of handling, since the dust resulting from abrasion is not magnetic and will be found as an iron content in the finished concentrate.

Blake-Moerscher Electrosiatic Process

At about the same time that the magnetic separation was instituted in Wisconsin, a small plant was built for purposes of testing out the Blake-Moerscher electrostatic process. This was an ingenious device, utilizing the differences of conductivity between the zinc blende and the marcasite. This first plant demonstrated that there was a strong possibility of this operation being successful, especially since the iron product had a marketable value as a source of sulphur, and made a salable zinc product.

In 1908 this process made its appearance in a slightly different form in the Huff electrostatic separator. A plant on a moderate scale, utilizing this process, was built and operated with more or less success for 3 years, when the plant was destroyed by fire and was not rebuilt. Probably the one determining factor in the abandonment of this process was the necessity of crushing the mill concentrates in order to effect a separation, which resulted in the liberation of lime and insoluble as described above.

Old and Primitive Methods Prove Best

The district as a whole has furnished its quota of incidents which have added to the general fund of mining and metallurgical experience. It has for the thousandth time been demonstrated here that metallurgists coming in from other districts should avail themselves of the experience of the natives, giving the prevailing methods careful thought before radical changes are decided upon. Nearly all of the mining and milling operations here are of almost primitive type, but when the outsider has attempted to improve materially upon these by any radical change, he has come to grief.

One feature of the average mining proposition here is that it is short lived, which of necessity means the cheapest installation that will make a respectable metal recovery and pay its entire cost, together with a profit, in from 3 to 5 years.

Another lies in the fact that concentrates must be re-treated before marketing. I have said above that nature has been most kind in providing physical properties which ultimately benefit the operation. A further instance of this lies in the fact that in a coarse jigging operation the percentage of recovery of zinc is much higher than that of iron. The average operation results in a metallic zinc saving of from 60 to 70 per cent. This large loss appeals to the outsider at once as an opportunity for radical improvement. He will find, however, in most cases that his efforts, which might be called metallurgically successful, will fail economically due to the fact that the product he recovers will not be worth its cost.

Flotation has not yet made its appearance except in the most superficial experimental way. This process does hold out some promise, especially on some of the larger propositions which have from to to 20 years' life, and I shall be surprised if within a very few years there are not some successful flotation plants operating in this field, especially since the selective processes producing zinc direct from other sulphides show strong promise.

Prospects for Future Development

Among the attractive features of the district—it is a most livable country, is traversed with better than average roads, and life here will be found to hold many compensations over that in the average mining camps. At first blush I should say that more in the way of prospecting and equipment can be accomplished per dollar here than in any other mining section I have seen.

It goes without saying that there have been the usual amount of wildcatting propositions. There have been also the usual well meant but misguided expenditures of capital. Altogether, the district will show a fair return on ventures well managed, and there are no reasons apparent why the present activity should not continue for another century.

Minnesota State-Owned Iron Mines

The following is a list of State-owned properties in Minnesota:

MINNESOTA STATE-OWNED IRON MINES

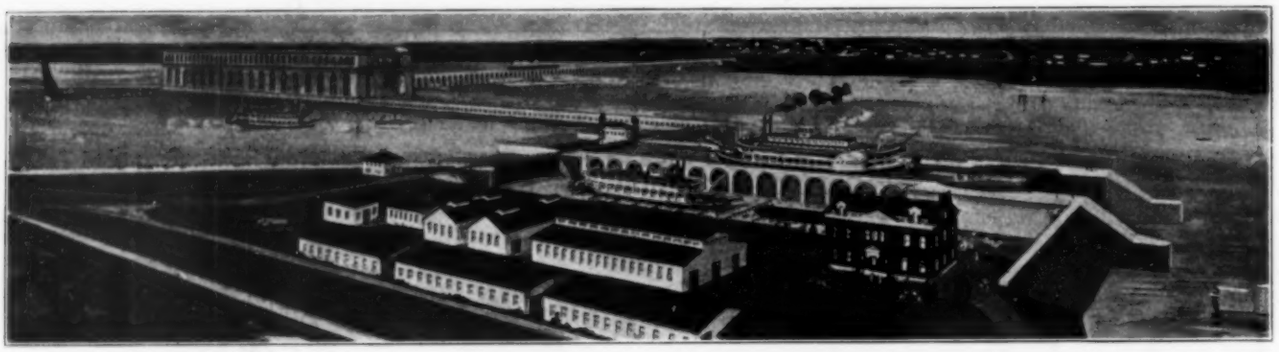
Mine	Operator	Tons Shipped in 1918
Missabe Mountain	Oliver Iron Mining Co.	1,173,312
Leonidas	Oliver Iron Mining Co.	656,735
Pool	Oliver Iron Mining Co.	191,434
Grant	Interstate Iron Co.	117,407
Hanna	Consumers' Ore Co.	116,082
Woodbridge	Fort Henry Mining Co.	209,414
Wacoutah "A"	Consumers' Ore Co.	174,442
Wacoutah "B"	Consumers' Ore Co.	947
Scranton	Pickands, Mather Co.	.....
Helmer	Cleveland-Cliffs Iron Co.	207,643
Duncan	Oliver Iron Mining Co.	5,159
Minnewas	Oliver Iron Mining Co.	.....
Fay	Virginia Iron Mining Co.	.....
Shiras	Oliver Iron Mining Co.	128,402
Frantz	Consumers' Ore Co.	169,777
Seville	A. B. Coates	7,703
Hill Annex	Interstate Iron Co.	559,727
Kevin	Butler Bros.	21,601
Philbin	Oliver Iron Mining Co.	233,484
Prindle	Oliver Iron Mining Co.	.....
Majorca	Hobart Iron Mining Co.	251,999
Morton	Dean Iron Co.	.....
Smith	Butler Bros.	39,292
Margaret	Butler Bros.	44,067
Wanless	Oliver Iron Mining Co.	175,587
Draper	Draper Iron Co.	.....
Pilot	Hanna Ore Mining Co.	.....
Thompson (Cuyuna Range)	Inland Steel Co.	152,648
Martin (Cuyuna Range)	Whitemarsh Mining Co.	1,421
Northland (Cuyuna Range)	Northern Minnesota Iron Co.	.....
Total		4,638,283

STATE-OWNED MINES NOW EXHAUSTED

Mine	Operator	Total Tonnage Shipped
Alberta	Loly Mining Co.	136,534
Cavour	Cavour Mining Co.	177,952
Section 17	A. B. Coates	20,802
Eaton	Eaton Mining Co.	3,547
Yates	Consumers' Ore Co.	678,990
Sliver	Virginia Ore Co.	174,813
Maderia	Maderia Mining Co.	195,494
Deacon	Oliver Iron Mining Co.	347,511
Total		1,735,643

Engineering and Mining Journal, vol. 108, No. 10, Sept. 6, 1919, p. 389.

HYDRO-ELECTRIC SYSTEMS, NORTH CENTRAL STATES



Power Systems of the North Central States

Hydro-Electric Systems and Large Steam Plants in Four States Offer Future for Electrochemical and Chemical Industries—Extension of Transmission Lines Opens Way for Development of Natural Resources

By CHESTER H. JONES

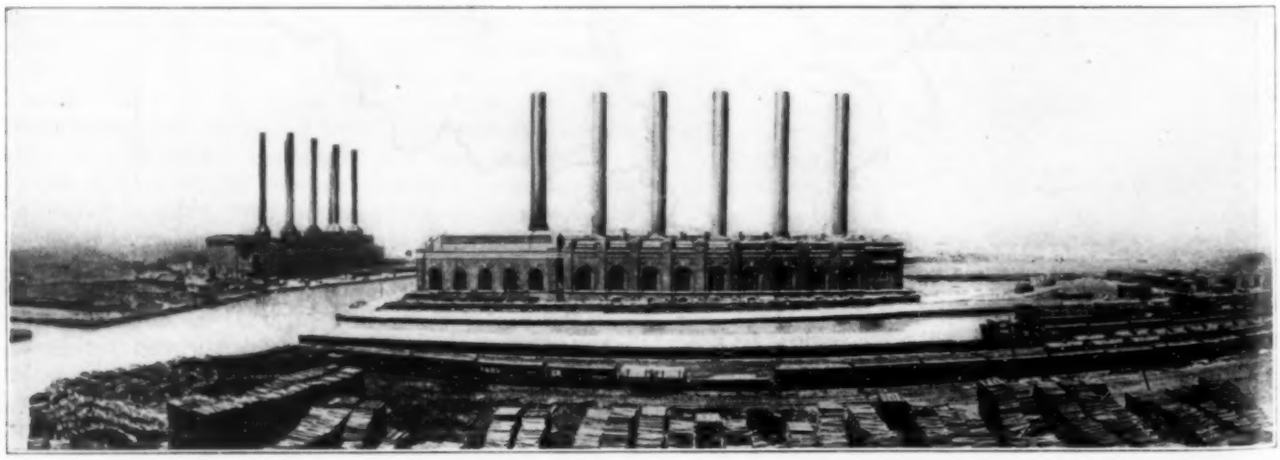
HYDROELECTRIC power in the district of four States of which Chicago is near the center has already become a factor in the development of the chemical industries, and an examination of the potential power resources of those States, individually, reveals the fact that vast coal areas supplying energy through large steam generating units supplement the water power stations to meet the demands of the territory. The district divides itself into the hydro-electric States of Wisconsin and Michigan, and the coal-bearing States of Illinois and Indiana. Keokuk Dam is the exception in the steam power areas. An examination of the map on page 343 will show the relation of local resources in water power to the total power in the United States.

Water-produced electric energy is not of necessity required for electrochemical manufacture. It is not to be forgotten in the consideration of the two sources of energy that a close competitor exists in the steam plant located near the coal supply. A good number of electrical engineers agree that hydro-electric energy transmitted over long distances, and supported by emergency steam plants, is subject to high cost, because of interest on investment, maintenance of line and steam plant and depreciation on system. For the future power of the chemical industry in Illinois and Indiana we must look to the coal fields.

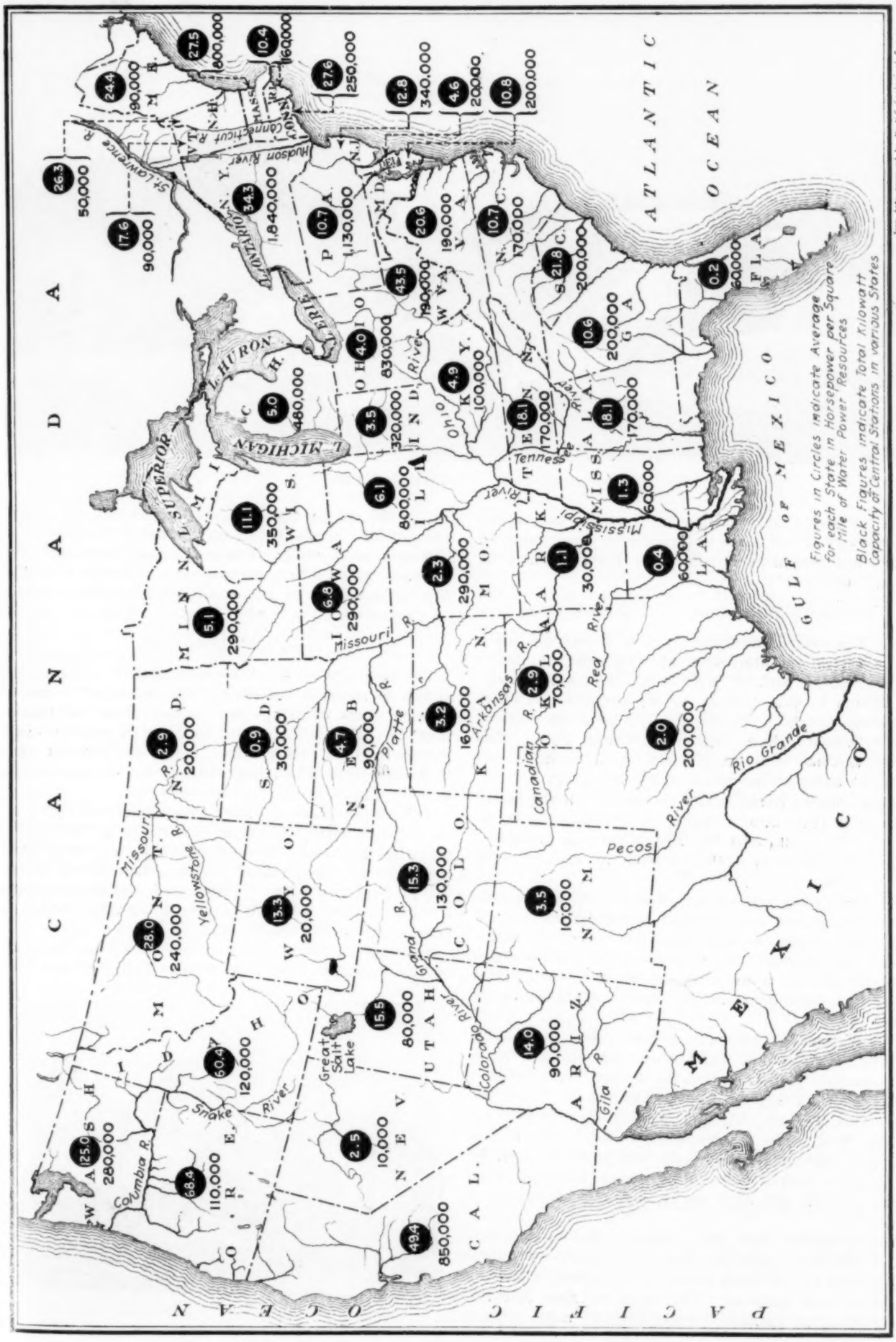
Wisconsin

The State of Wisconsin is peculiarly adapted for water-power development. The slope of the land lies in one direction, commencing at a ridge about 30 miles from and parallel to the shore line of Lake Superior, sloping to the southwest, the entire drainage flowing into the Mississippi River. The many lakes act as reservoirs for each local drainage area, making it possible to hold the storm waters and thus to secure an ideal condition for continuous operation of water-power plants.

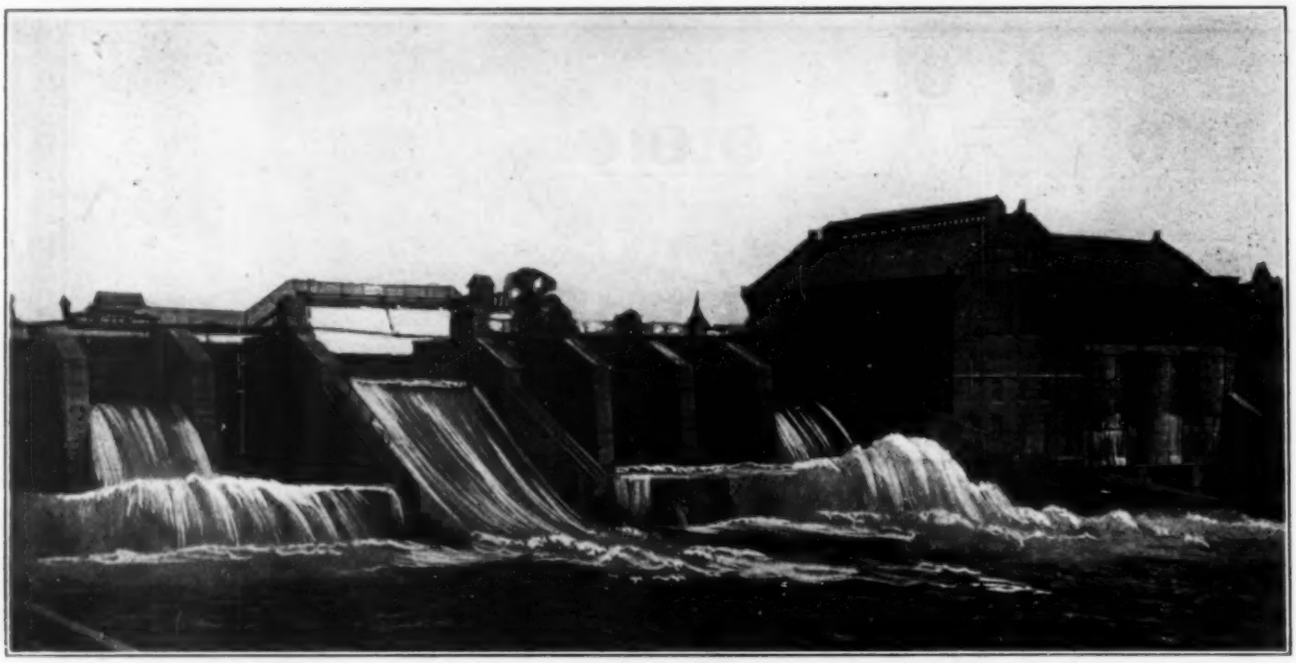
The total capacity of generating plants, both steam and water-power, within the State is 350,000 kw., with a possible hydro-electric generating capacity of 613,342 kw. There are now installed 129 hydro-electric plants, the majority of which are of small capacity. The field for future development of water power will be seen from these figures to be enormous.



FISK AND QUARRY ST. GENERATING STATIONS, COMMONWEALTH EDISON CO.



HYDRO-ELECTRIC POWER RESOURCES IN THE U. S.



CROTON DAM, MUSKEGON RIVER

The extension of transmission lines in the southwestern part of the State is forming an interconnected system, and should eventually serve the consumers as a single unit.

Wisconsin-Minnesota Light & Power Co.

The Wisconsin-Minnesota Light & Power Co. operates a series of interconnected hydro-electric plants in the western part of Wisconsin, furnishing power, in addition to this district, to Minneapolis and other Minnesota points. The principal generating stations are at Wissota, Eau Claire and Cedar Falls. The largest of these is at the Wissota Dam, located on the Chippewa River at the outlet of Wissota Lake.

The Chippewa River is the greatest of all the power streams in the State, carrying at the Falls a drainage of 5600 sq.m., and the Red River, its tributary, brings an additional drainage from an area of 1997 square miles.

The generating station equipment at Wissota power house consists of six 6600-kw. water-driven vertical generators, together with necessary auxiliary apparatus. Transmission line operates at 110,000 volts, and about 30,000 kw. is consumed by the Northern States Power Co., operating in St. Paul and Minneapolis, Minn.

The stations at Eau Claire and Cedar Falls each contain four 6500-kw. water-wheel generators. Other hydro-electric plants are located at Red Wing, Minn.; Cedar Falls, Chippewa Falls, Menomonie, Neilsville, Rice Lake, Stanley, Viroqua, Sparta, Tomah and La Crosse, Wis. The transmission voltages are 13,200, 33,000, 66,000 and 110,000 volts, and power is supplied to railroad shops, pulp mills, sugar factories, tire factories, iron and steel works, and miscellaneous industries.

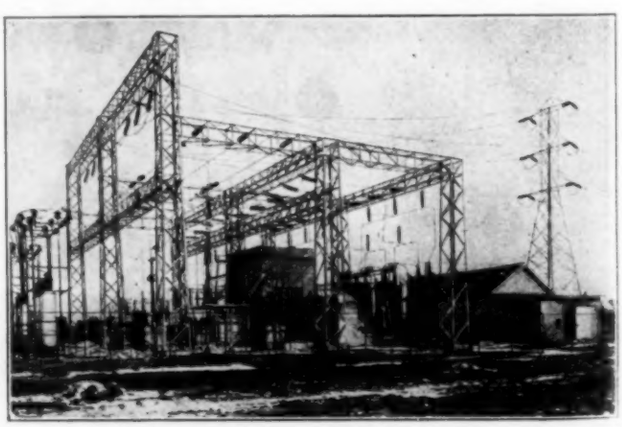
Interconnected with this system is that of the Wisconsin Railway, Light & Power Co., with its water-power plant on the Black River, near Hatfield, below the outlet of Lake Arbutus. The water is taken into the power canal at Hatfield, transmitted 2.6 miles with a fall of 94 ft. to the power house, where it enters through two tubes 10 ft. in diameter to drive two 3200-hp. water wheels. Power is transmitted over No. 2 copper wire to Winona, where it connects with the Wisconsin-Minnesota Power Co. system and with the La Crosse Co.

Wisconsin Edison Co.

The property of the Wisconsin Edison Co. consists mainly of steam-power plants interconnected by transmission lines covering the district from Milwaukee west to Lake Mills, south to Delevan and through Burlington back to Milwaukee. A line also extends from Milwaukee through to Kenosha. Power is transmitted at 4000, 13,200, 26,400 and 66,000 volts.

This system receives power from hydro-electric plants of the Southern Wisconsin Power Co. at Kilbourne, utilizing the total output of 6000 kw., and also from the hydro-electric plant of the Wisconsin River Power Co. at Prairie du Sac. This latter station generates a total capacity of 16,500 kw. at 2200 volts, 25 cycle, from a total of six machines.

An examination of the map will show that majority of the water-power plants in Wisconsin are not con-



OUTDOOR SUBSTATION, MUSKEGON HEIGHTS

nected with any considerable lengths of transmission lines, outside of the above mentioned plants. One of the larger plants of the State is at St. Croix Falls, located on the St. Croix River and furnishing power for stations in Minnesota. This station contains six units generating 15,000 kw. and delivering energy to the transmission line at 6600 and 66,000 volts.. There is also a station at Somerset on the same river which has a capacity of 3000 kw., with four units all delivering power principally to the St. Paul Co.

Michigan

The State has a total potential water-power resource of 294,500 hp. and a present steam and water power available in generating stations of 480,000 kw. One hundred and sixteen hydro-electric plants in whole or in part are in operation. The majority of these are isolated plants or systems with short transmission lines. The largest system in the territory in number of plants and length of transmission lines is the Consumers Power Co., a Hodenpyl-Hardy property.

Consumers Power Company

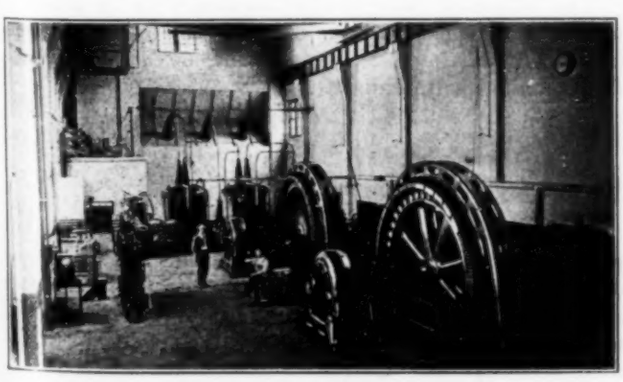
This system, starting with a chain of six water-power generating stations on the Au Sable River, transmits energy south through the Saginaw district, through Lansing to Jackson and Battle Creek, connecting in with six hydro-electric plants on the Kalamazoo River, thence northward to plants on the Grand, Muskegon and Manistee rivers, forming a horseshoe system over the territory of the Lower Peninsula.

One of the large chemical works using this energy is that of the Dow Chemical Co. at Midland, where bromine, bromides, chlorine and miscellaneous chemicals are produced. Other plants along the line are the Michigan Alkali Co. at Wyandotte, manufacturing soda ash, and the North American Co. at Bay City, manufacturing soda ash and chlorine.

The Pennsylvania Salt Co. at Detroit, making chlorine and alkalis, is on the line of the Detroit Edison Co.

Among other developments on the Au Sable River is the Cooke power house. On the southern loop of the system additional energy is generated at Grand Rapids, Jackson, Saginaw, Bay City, Battle Creek, Kalamazoo, Pontiac, Manistee and Cadillac. The hydro-electric plants have an installed capacity of 101,000 hp., and the steam plants 103,000 hp., i.e., the total is equal to nearly half of the total installed power in the State. There are 1400 miles of transmission lines, steel tower construction, located almost entirely on private rights-of-way.

In addition to power furnished for the chemical industries above outlined other prominent industries are factories for automobiles, agricultural machinery, food products, paper and pulp mills, brass and metal products, stoves, wagons, and also electric railways. The field for development of ceramics is said to be large along this property; this is also true of several large undeveloped chemical deposits.



INTERIOR COOKE POWER HOUSE

Among the larger water-power plants in the north are Junction Dam on the Manistee River and Croton Dam on the Muskegon River. The pictures shown herewith give a good idea of the Croton Dam and a substation in this section. Reference to the map will show the proximity of the transmission lines of the Detroit Edison system to this property and doubtless it will not be long until interconnection is made to form a system that will serve the whole Lower Peninsula.

The Detroit Edison Co.

This company is controlled by the North American Co. and operates the largest system of steam generating plants in the State. Energy is also supplied from four hydro-electric plants on the Huron River, near Ann Arbor. The two plants at Detroit generate from steam a total of 198,000 kw. The total water-power capacity near Ann Arbor is 6075 kw.

Upper Peninsula Plants

The Escanaba Power Co. operates hydro-electric plants on the Escanaba River at Groos, Wells and Chandler Falls with a total of 3750 kw. capacity transmitted at 6600 volts.

There is a 3000-hp. water-power plant under construction at Superior Falls, Wisconsin, for the purpose of supplying energy to Ironwood and Bessemer, Michigan.

A 3700-kw. plant on the Menominee River supplies energy to Menominee over a 3300-volt transmission line. There are also similar plants at Newaygo, for the Portland Cement Co., at Sault Ste. Marie, and at Marquette all in northern Michigan.

Illinois

The total electric power generated in the State of Illinois is 400,000 kw., which is produced chiefly from coal, with the exception of 17 hydro-electric plants. The principal water-power property is that of the Mississippi River Power Co. at Keokuk, Ia., while other plants worthy of note are the Public Service Co.'s generating station at Joliet, and the Sanitary District plant at Lockport. The total potential waterpower of Illinois is 345,660 hp., which exists chiefly in the Mississippi and Ohio rivers. The development of this power would be expensive, the flat topography necessitating the condemnation of large farming areas or the construction of heavy dikes. Reference to the article on raw material resources elsewhere in this issue will show the nature of the coal supply, and this coal is proving a better source of power than water for the territory.

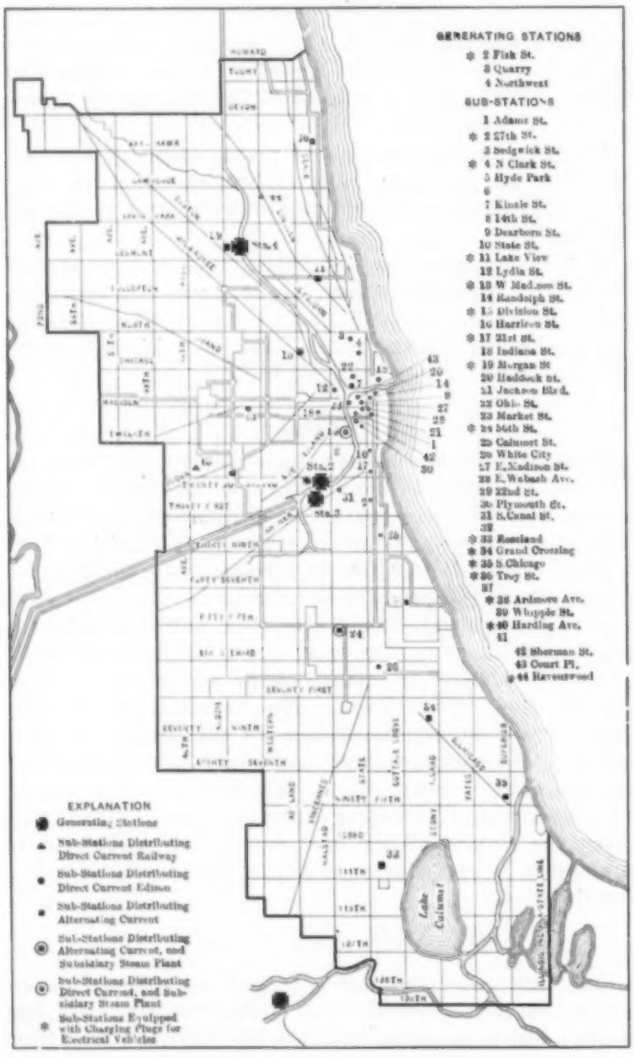
Mississippi River Power Co.

Standing out pre-eminent beyond all other developments in this district and remarkable among the world's hydro-electric plants, the 231,500-kw. generating station of the Mississippi River Power Co. at Keokuk, Iowa, is too well known to be described in detail in this article. The plant is located in a section where

many raw materials are available for electrochemical reduction. The station contains thirty turbo-generator units with an overload capacity of 13,500 hp. per unit and transmissions are built as shown with the possibility of continual extension. Current is generated at 11,000 volts and transmitted at 110,000 volts. Of the total power generated 60,000 hp. is sold in St. Louis and a smaller amount to the smaller cities on the line. With 200,000 hp. now offered for sale there is still left a sufficient amount for large developments that may be desired.

In the construction of the dam and installation of the electric equipment, every imaginable contingency was considered, thus securing a reliable operation for many years to come. The dam proper, built out from the Illinois bluff, is of the gravity type and withstands all pressure upon it by virtue of bulk without bracing or reinforcement. The turbines and generators are specially designed by the best engineers available and are absolutely dependable as to operation.

The Mississippi River Power Co., with its plant on the Iowa side of the river at Keokuk, transmits energy into Illinois, after which the line follows the river to Hulls, Ill., where tap is taken off for a cement plant at Ilasco, Mo. Energy is then transmitted further down the river on the Illinois side, crossing just above St. Louis with the line supplying the city. Energy is also furnished to Alton, East St. Louis and Bellville, Illinois.



GENERATING AND DISTRIBUTING POINTS, COMMONWEALTH EDISON CO.

The Alton substation is one of the distribution points for the high tension service as well as that from the local steam plant. Incoming 66,000-v. lines and the outgoing 13,200-v. lines terminate here. The outgoing 66,000-v. power is carried over steel towers to a substation in East St. Louis. This line is brought through the Alton substation so that all the 66,000-v. energy received from Keokuk may be measured. There are two 13,200-v. 25-cycle lines connecting Alton and East St. Louis substations, while two additional 13,200-v. lines supply local points. The operating statistics of the Alton substation should show a good comparison between production costs of steam power, generated locally, and hydro-electric power transmitted over long distances.

The Central Illinois Public Service Co. operates a 2500-kw. frequency changer set in the Mississippi River Power Co.'s power house at Keokuk, Ia., and through this unit energy is supplied to the system which stretches across the central portion of Illinois. The 25-cycle energy from the water-wheel generators is converted to 60-cycle 11,000-v. energy which is conducted through conduits in the dam to the Hamilton substation on the Illinois side, where it is stepped up to 33,000 v. for the transmission lines. The line from Hamilton to Colchester is the second link for Keokuk power to the Central Illinois Public Service Co. This development releases 2000 tons of coal per month for use at other steam plants. It is stated that the operating expense is not reduced by the new supply, but additional capacity is secured and reliability of operation effected.

Other Water Powers

The Public Service Co. generates a total of 5778 kw. by water power, with its principal plant located at Joliet. This plant generates a total of 3600 kw. and is connected to a part of the company's transmission system. The property as a whole depends upon steam plants, however. The Sanitary District of Chicago receives power from its 35,000-hp. hydro-electric plant at Lockport. This power is consumed principally for street lighting within the District and has recently been increased by the completion of an auxiliary steam plant, 4000-kw. capacity, located at the terminal station, West 31st Street and Western Avenue, Chicago.

Steam Plants

The Commonwealth Edison Co. of Chicago, by virtue of territory served, is the largest steam generating system in the State. The accompanying outline map shows location of generating and distributing points.

The following table shows the statistics in percentages of the connected loads of the plants of other companies within the Chicago territory as compared with the Commonwealth Edison Co.:

Company	Lamps — Incandescent, Per Cent	Lamps — Arc, Per Cent	Motor Horsepower Per Cent
Commonwealth Edison Co	95	96	89
Other companies	5	4	11

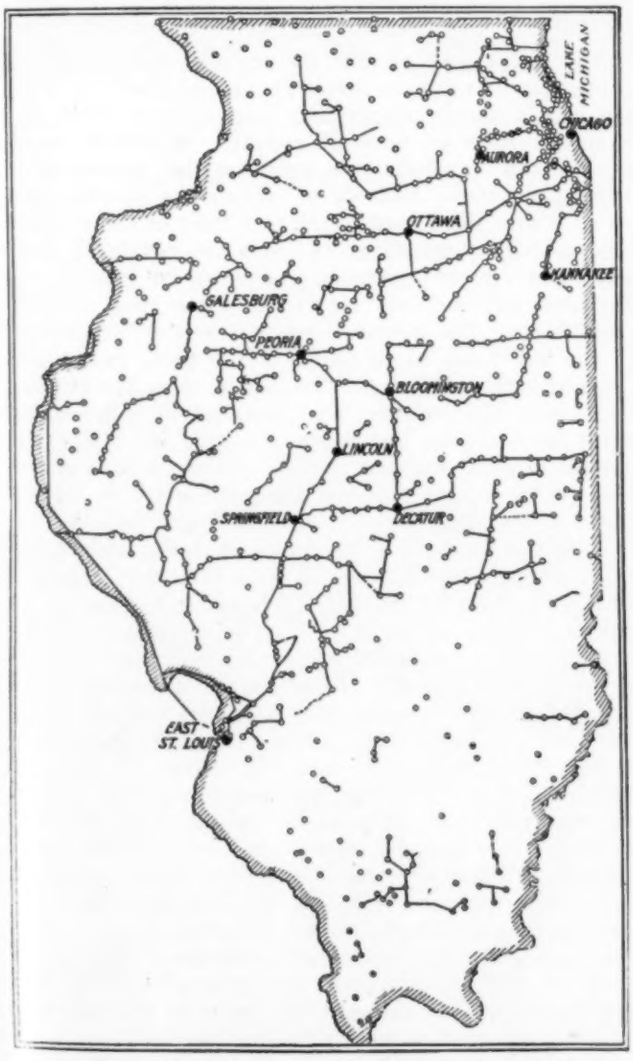
The generating equipment is located in three principal power plants. The downtown and southern end of the city is served from the Fisk and Quarry street stations with a combined rating of over 200,000 kw., while the northern section is served from the Northwest station. The distribution of load between sta-

tions is handled from the load dispatcher's office. Every facility for securing information in the shortest possible time is placed in the hands of this dispatcher. Maps, private telephone system, etc., are available for any emergency situation.

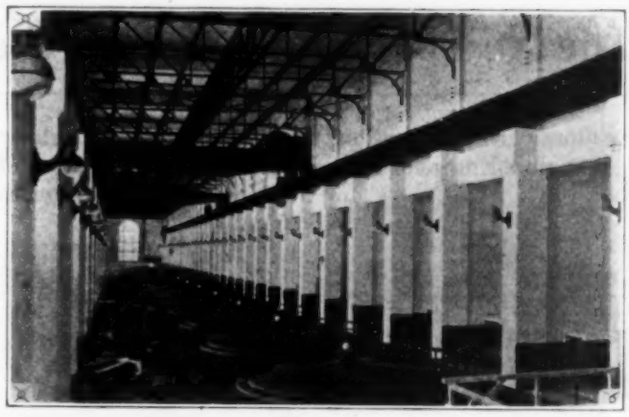
One of the features influencing the sale of power to chemical and electrochemical industries is the lower selling rate quoted for use of current during periods of the off-peak loads. In order to make the demand on the generating plants as uniform as possible the company may offer the use of power at certain times of the day at such a price per kilowatt-hour as to permit its economical employment in some of the chemical or metallurgical processes. This should apply to chlorine, and oxygen manufacture, where the operation may be intermittent.

Interconnecting Transmission Lines

Supplementary to the general hydro-electric map appearing on page 341 the outline sketch herewith shows transmission lines owned by 28 companies in this locality. A considerable number of these companies are already interconnected for service interchange. There are also several connections between systems in Illinois and those in neighboring States. The Central Illinois Utilities Co. has a connection with the system of the Interstate Public Utilities Co. of Indiana. This connection, it is understood, is used only for emergency purposes on account of the difference in load characteristics of the two systems.



INTERCONNECTED TRANSMISSION LINES OF ILLINOIS



GENERATOR ROOM, KEOKUK, IOWA

The East St. Louis Light & Power Co. has connection with the Union Electric Light & Power Co. of St. Louis by means of submarine cable under the Mississippi River. The contract covering this service was recently authorized by the Illinois Public Utilities Commission. The cable is now in use and is mainly for the purpose of supplying emergency and peak service to East St. Louis.

The larger companies operating in Illinois besides those mentioned are the Illinois Traction System, covering a large district in central Illinois; the Middle West Utilities Co., composed of a number of smaller plants, in the sparsely settled districts throughout the State; the Public Service Co. of northern Illinois, and the Southern Illinois Light & Power Co.

Indiana

The flat topography of Indiana does not lend itself to any considerable water-power development, so the State must depend upon its large coal supply for power. The total installed generating capacity is 320,000 kw., being steam units with few exceptions. A water survey of the State shows power available for hydro-electric development as 126,000 hp., considerable part of which lies along the drainage area of the Wabash and Ohio rivers. The steam plants of the State are interconnected by adequate transmission systems radiating from Indianapolis.

The total number of steam properties within the State is 185, as compared with 224 in Illinois. The principal companies operating these former properties are: The Union Traction Co. of Indiana, the Indiana General Service Co., Interstate Public Service Co., Ft. Wayne & Northern Indiana Traction Co., Northern Indiana Gas & Electric Co., Indianapolis Light, Heat & Power Co., Indiana Railways & Light Co., Terre Haute Traction & Light Co.

One of the large manufacturing districts is served by the Northern Indiana Gas & Electric Co. at Michigan City, Hammond and East Chicago.

The one hydro-electric system of importance in the State is the property of the Indiana & Michigan Electric Co., with dams located at Elkhart, Ind., Berrien Springs and Buchanan, Mich. The transmission line serves South Bend, Michigan City and intermediate substations. The system is also supplied with power from steam plants at South Bend and Elkhart. Total water-power capacity is 20,000 hp. installed.

The Need for Research in the Non-Metallic Mineral Field*

Economic Importance of the Industry of Inorganic Non-Metallic Minerals — Need of Investigations and Engineering Studies on Their Value and Adaptability to Other Industries—Influence of the Non-Metallics Upon the Daily Life of a Community

By RAYMOND B. LADOO†

INDUSTRIAL problems brought out by the war and by the reversion from war to peace conditions have made necessary many changes of practice and methods which will result in the conservation of material resources, energy, efficiency and man power. Research is always necessary, but to-day it is particularly important. But our programs of research also need revision. In the mining and mineral industries a survey of the whole field is necessary to determine what fields have been covered, what fields should be covered, and what are the present problems in such fields.

All mining and metallurgical industries can be divided into three well defined groups: (1), the metal and alloy group; (2), the organic non-metallic group; and (3), the inorganic non-metallic group. The first group comprises the major and minor metals and their alloys. The organic non-metallic group includes coal, lignite, peat, petroleum, natural gas and other natural fuels. While it may be questionable if petroleum is of organic origin, for the purposes of research and investigation it logically falls within this group. The inorganic non-metallic group includes granite, sandstone, limestone, marble, slate and other structural stones; sand and gravel; limestone, dolomite, fluorspar and other fluxing stone; cement; clays and clay products; glass sand and

GENERAL VIEW OF ELMHURST-CHICAGO STONE CO. QUARRY, ELMHURST, ILL.

glass; feldspar, flint, and other ceramic materials; salt and salines; phosphate rock, potash salts and other fertilizer materials; emery, corundum and other abrasives; magnesite; asbestos; mica; chalk, bauxite; talc and soapstone; gypsum; fuller's earth; graphite, etc.

Research in the metal group has been important for several decades. The need for research in the organic non-metallic group has been emphasized during the war and, while much work remains to be done, this field is now receiving much attention. The inorganic non-metallic group, however, has received but comparatively little attention by mining and metallurgical engineers. The economic importance of this group is great, and it is worthy of careful study.

Most of the minerals of this group are used as mined with but little modification, and their physical properties are preserved without change. Noteworthy exceptions to this are the manufacture of glass from glass sand, and cement from limestone and clay or shale. In the latter industries, the manufacture of glass and cement corresponds to the smelting or other metallurgical treatment of the metals. But in most instances the value or suitability of a non-metallic mineral depends upon preserving intact, in the finished products, its original physical and chemical characteristics. Thus the fibrous structure of asbestos, the platy structure of mica and the soft, white, greasy characteristics of talc are essential to their use.

Importance of Group Not Generally Recognized

The importance of this non-metallic group and its proper place in mining investigation and literature have not been generally recognized. Quarrying is really but a special form of open-pit mining. Moreover, many non-metallic minerals are produced by underground mining methods. Methods of milling are strictly comparable with those used in the treatment of the metallic ores, and the "metallurgy" of such non-metals as glass sand and cement materials makes use of machinery, furnaces and methods similar to those used in true metallurgy. The largest screening and milling plants in the world are to be found in the sand, gravel and crushed rock industries. The largest gyratory crusher ever built has recently been installed at a limestone plant in Michigan, and likewise one of the largest, if not the largest, washing plant in the world is in operation in Michigan, washing limestone used as fluxing stone in the smelting of iron in the blast-furnace.

There are probably several reasons for this comparative oblivion. The intrinsic value of the crude materials in the ground is often low in comparison to that of the metals. Such materials as clay, sand, limestone and soapstone do not appeal to the average miner or prospector as do the metals. They are not surrounded with the glamour and romance that has made the search for the metals full of interest since prehistoric times. Another reason is that the value of many non-metallics depends largely upon collateral conditions, such as local demand, proximity of markets, freight rates, size and availability of deposits, rather than on intrinsic value. Copper or silver ores have a definite value depending upon their metal content, and the prospector does not have to consider how to market his product. Clay, talc, limestone and mica require a knowledge of market possibilities, and thus the needs for definite knowledge and engineering and business ability are even greater. The winning of most non-metallics has seemed easy compared to that of metals; and consequently little atten-

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†Mineral Technologist, Bureau of Mines.

FACE OF QUARRY, MAGNESITE MINE

Northwest Magnesite Co., Chewelah, Wash.

ROTARY (CALCINING) KILNS AT REDUCTION PLANT

GENERAL VIEW OF HURON PORTLAND CEMENT CO. QUARRY, ALPENA, MICH.

tion has been paid to these subjects by the engineer. In the past many non-metallic mines and quarries have been started and run in a small, inefficient way by farmers or others as a side line. They have not, as a rule, until recently been considered as engineering problems of a magnitude comparable with metal mining operations, or as business propositions.

Economic Importance of This Mineral Group

That this mineral group is of great economic importance is shown by the following statistics compiled for the year 1916 by the U. S. Geological Survey in which the figures have been changed to round numbers. The total value of all mineral commodities was about $3,500,000,000. The combined value of groups 1 and 2, or the metal group and the organic non-metallic group, was about $3,000,000,000, while the value of group 3, the inorganic non-metallic group, was about $500,000,000. Thus there was a ratio of 6 to 1 between the combined values of groups 1 and 2 and group 3. If all of the minerals and metals are arranged in descending order of value, clay stands third in the list, being only preceded by coal, iron and steel.

METHOD OF MOVING A CHANNELING MACHINE WITH A DERRICK, BEDFORD, IND.

Evidence of the small amount of work already done in this group may be obtained by an examination of the shelves or index of a large mining library or by consulting volumes of the transactions of any large mining and metallurgical society, such as the American Institute of Mining and Metallurgical Engineers. It is safe to say that there are at least fifty volumes relating to the metallics to one relating to the non-metallics. It is probable that, taking all mining and mineral literature, research and investigations together, this discrepancy would be far greater. There are a hundred consulting engineers in the one group to one in the other. Our technical mining and metallurgical societies

ANOTHER VIEW OF HURON PORTLAND CEMENT CO. QUARRY, ALPENA, MICH.

contain few members interested primarily in the non-metallics, and their publications contain very few references to technical work in this group. Research and investigation in this group would improve methods of mining and milling, increase safety and efficiency, decrease waste, find new uses and wider and more varied markets, make available large deposits of valuable minerals not now workable and improve the preparation of many domestic products so that we might be independent of foreign sources of supply.

Influence of the Non-Metallics on Daily Life

Let us consider for a moment the influence of the non-metallics upon the daily life of the community. All large buildings are preponderantly non-metallic. They are built of stone or brick, tile, terra-cotta or concrete. Highways are stone, brick, concrete or asphalt and crushed rock. Large dams, dry docks, piers, breakwaters, bridges or bridge foundations, fortifications, subways and lighthouses are all built wholly or in major part of non-metallic mineral products. Water-distributing systems use concrete in the construction of dams, and sand and gravel in filtration plants; sewerage systems use clay sewer pipe. Metallurgical industries use limestone, dolomite and fluorspar fluxes; silica, clay, magnesite, dolomite, chromite and graphite refractories; abrasives, minerals, pigments, molding and filtering sand, and asbestos, and magnesite heat insulations. In almost every home are tiled bath rooms with their sanitary porcelain fixtures, living rooms with their marble or tile mantels, and tile, brick or stone fireplaces, glass mirrors, windows, lighting fixtures and glass-protected pictures, dining rooms with all their china, porcelain and glassware, the enamel on cooking

GENERAL VIEW OF THE BEDFORD, IND., LIMESTONE QUARRIES

utensils and sinks, asbestos mats, mica lamp chimneys and mica insulations in electric flatirons, basements with concrete floors, with their furnaces and pipes protected by asbestos and magnesia pipe-coverings and cements, and laundries with soapstone sinks and tubs. There is not a phase of our everyday life that is not touched directly or indirectly by the non-metallic minerals. Even the newspapers and magazines which we read use clay, talc, gypsum, chalk or other minerals as fillers and coatings. Rubber automobile tires contain talc, clay, magnesite or chalk as a filler; brake linings are of asbestos.

The importance of many of these things is often unrealized until supplies are suddenly cut off. During the war imports of Grecian and Austrian magnesite, Ceylon and Madagascar graphite, Italian, French and German talc, English fuller's earth, English china clay, German potash salts and other vital mineral commodities were cut off entirely or greatly reduced. Immediately our industries felt the loss and our war activities would have been crippled seriously had not domestic sources been immediately developed and by research adapted to our needs. If we had not possessed large resources of common salt, our great production of chlorine and other asphyxiating gases would have been impossible.

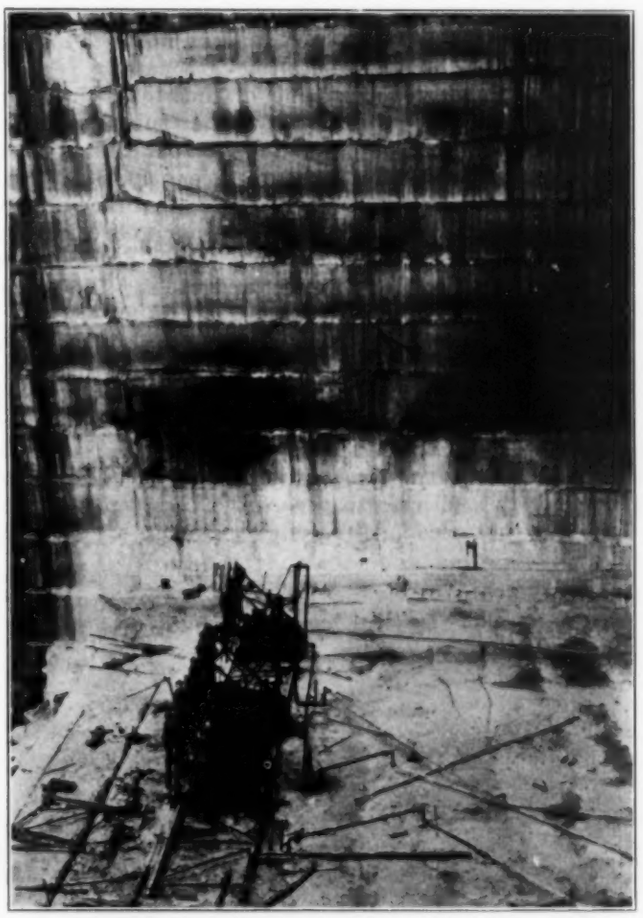
Field a Wide One

The problems and needs for research are as great in the non-metallic fields as in the metallic. Quarrying seems simple, but there is a large and almost untrodden field here for the application of modern engineering and mining principles. The methods of mining, milling and grading of talc and the mining, trimming and grading of mica offer fields for great improvement. It has been stated that domestic mica could fill all of the needs of this country, if properly trimmed and graded, yet over 60 per cent of the mica used in the country is imported. There are vast resources of high-grade clays in this country, but owing to improper methods of mining, washing, grading and blending, they are not considered satisfactory for our best porcelain and paper, and a very large amount of such clay is imported from England.

The chemical and physical properties of the metals have been accurately measured and standard tests of strength, composition and purity have been devised. Most metallic products are now purchased on specification, and checked up by standard tests. It is of interest to note that very few standard tests have been devised for the non-metallic minerals or their products, and few specifications are used in purchasing. Each producer makes certain grades which are in accord with his own ideas, but practically no two producers in certain industries offer the same or comparable grades. Consumers do not even know what grades are best suited to their needs. This creates confusion and dissatisfaction, and in the long run greatly injures the producer. For example, a papermaker may be induced to try talc as a substitute for English clay as a filler. The grade of talc which he tries may be totally unsuited to his uses and prove a failure. That papermaker then concludes that the use of talc in his paper is impossible and he condemns talc in general. A different grade of talc, intelligently selected from standard specifications, might have been found far superior to English clay. The lack of standardization of caustic magnesite for the plastic flooring industry has caused great dissatisfaction with California magnesite for this purpose. Doubtless this has been one of the factors in the lack of development of California magnesite for use in the flooring industry.

Our non-metallic minerals are more valuable than is ordinarily supposed. English china clay sells for over $30 per ton, Italian and French talc for $60 per ton, and asbestos No. 1 crude for over $1,500 per ton. Even fluxing limestone sold for $2.50 per ton or more in certain sections during the war. These values compared favorably with those of many of our metallic ores.

It has been argued that the mining problems in the non-metallics are the same as those in metallics, and that a consulting engineer experienced only in metallic ore mining can successfully enter the non-metallic field. So he can, if he is willing to make a detailed study of the new problems involved. But the non-metallic problems are usually very different from those in metallics.



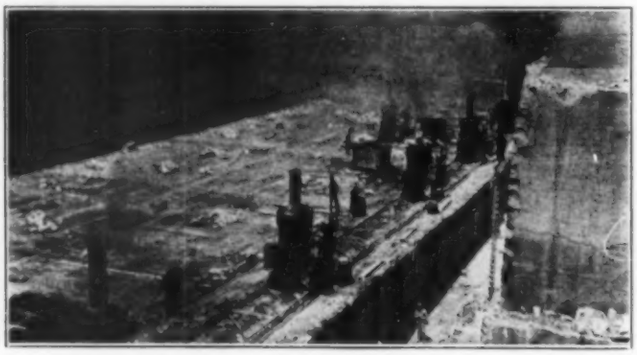
INTERIOR VIEW OF A GEORGIA MARBLE QUARRY

MILL NO. 3, EASTERN TALC CO., ROCHESTER, VT.

For example, in the quarrying of structural stone, the shape and size of the finished blocks are important. Fault and joint planes, color and grain, hardness and texture must be considered. The machinery involved is different. Few metal-mining engineers are familiar with the use of channeling machines or sawing, grinding and polishing machinery. In mining talc to be used for ground talc, grit must be excluded and iron-bearing surface water must not be allowed to discolor the talc. If the talc is to be sawed into crayons, or used for "lava" (baked talc used for gas burner tips and electrical insulation), it must be removed underground in large, sound blocks. In the milling of asbestos, the ore must not be left too long in a "breaker," or the fibers will be broken. In the mining of mica, large plates must not be broken by drilling or blasting. The white color of kaolin must not be spoiled by surface water or a mixture with iron-bearing clay or overburden. In preparing magnesite, care must be taken to exclude all dolomite or other lime-bearing carbonate.

In the underground mining of limestone, the value of the product is such that very little timbering can be afforded and methods of mining without timber must be used. Few metal-mining engineers appreciate the great difference between the two fields, and they are apt to minimize the essential distinctions, or to overlook the importance of this field entirely. These problems are often very difficult of solution, and call for the use of the best engineering skill, backed up by experience.

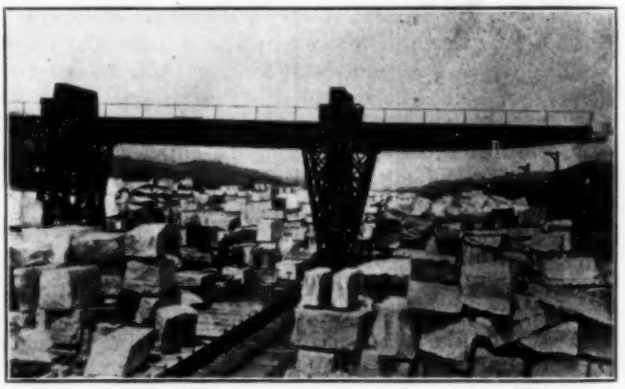
Another field of research in this group is that of determining accurately the physical and chemical properties of many minerals, looking toward the discovery of new uses. A good example of this is the mineral talc. Contrary to the impression which prevails in the minds of many, the principal use of talc is not for talcum powder, but as a filler for paper. Probably 80 per cent of the talc consumed in this country goes into the manufacture of paper. But there are many other important uses, among which are the roofing, paint and rubber industries, foundry facings, fillers for cotton cloth, "lava" gas tips and electric insulation. Over forty uses for talc are now known, many of which were developed during the last few years. But these uses could be greatly expanded if all of the chemical and physical properties of talc were studied and tabulated. For example, the colloidal properties of finely ground talc should be studied to determine further possibilities of talc as a lubricant in a water or oil suspension. The hardening of talc under heat is utilized in the manufacture of "lava," and research might extend this use. The presence of grit and dark color in some ground talcs is objectionable for many uses. These objectionable points might be eliminated by better methods of grinding and grading or by chemical treatment.



CHANNELING MACHINES AT WORK, BEDFORD, IND.

The subject of clay is one upon which much has been written, though there is little of permanent value. Of the best methods of mining and washing clays very little is known, and practically nothing has been published.

Within the last few years the producers of non-metallic minerals have begun to realize the importance of their industries and have awakened to the possibilities of expansion. Producers' associations have been formed



TRAVELING CRANE AT VERMONT MARBLE CO. STOCK PILE, WEST RUTLAND

with energetic technical and publicity committees. Advertising campaigns aimed to educate the public and popularize their products have been inaugurated, and as a result great progress has been made. Many persons who had never heard of magnesia a few years ago are now using magnesia pipe coverings in response to the slogan, "Let 85 per Cent Magnesia Defend Your Steam." A good beginning has been made and great expansion in this group of minerals seems inevitable.

Summary

1. The great economic importance of the inorganic non-metallic minerals cannot be denied.
2. Literature, research and investigations in this field have been very meager and unsatisfactory.
3. The intrinsic values of the individual minerals are large enough to attract the best engineering and business talent.
4. Mining and milling problems in the non-metallics are different from those in metallics and often are not appreciated by metal mining engineers.
5. A comparatively untrodden field lies open for consulting mining engineers and industrial chemists.
6. All present tendencies indicate a period of great expansion in this field in the near future.

Glucinum

An Introduction Intended to Encourage the Metallurgical and Chemical Development of the Industry of Glucinum, Its Alloys and Salts—Abundance of the Glucinum Minerals—Description of Some Relatively Successful Methods Employed for the Production of Glucinum Metal

By J. S. NEGRU

THE minerals of glucinum have been, and to some extent still are, considered useful only as precious stones for ornamental purposes, but only an infinitesimal quantity of these minerals is found to be of sufficient purity and beauty of color to make them valuable as ornaments. The minerals of lower quality were, and still are, practically useless, and their mining is neglected. There is an abundance of glucinum minerals in the United States and elsewhere, some of them in crystals weighing about 60 lb. (gadolinite, Texas) and even about 2900 lb. (beryl, New Hampshire). According to J. H. L. Vogt[1] between 0.01 per cent and 0.001 per cent of the entire earth's crust is glucinum. The progress realized in industrial chemistry has opened new aspects as to the value of these minerals for their glucinum content.

Vauquelin First to Discover Existence of Glucinum

In 1797 the mineralogist Haüy, having found that the minerals beryl and emerald have the same physical structure, hardness and specific gravity, entrusted L. N. Vauquelin with the work of determining whether these minerals were also of identical chemical composition. Vauquelin, besides proving that they are identical chemically, also discovered that they contain an oxide which until then was considered to be alumina, but which he separated from the alumina by the precipitation occurring when the caustic potash solution of the hydrates is concentrated by boiling. He studied this new product and assigned to it many distinctive properties, of which the most characteristic are: Its salts are sweet and lightly astringent; soluble in dilute ammonium carbonate; insoluble in ammonia; does not form alums; absorbs ½ of its weight of carbon dioxide; decomposes salts of alumina. He has given to the oxide a place between alumina and magnesia. Due to the fact that the salts of this new oxide are sweet, it was named glucina.[2]

Humphry Davy attempted to reduce glucina with potassium vapors, but without success. He then fused glucina with iron filings and potassium in a clay crucible, dissolved the fused mass in water and obtained a residue of a semi-malleable mass. This was in reality a glucinum-iron alloy.[3]

F. Wöhler in 1827 was the first to succeed in isolating glucinum metal. He worked on the chloride obtained by mixing glucinum hydroxide with carbon and heating the mixture to red heat in a current of chlorine gas. He placed in a platinum crucible a layer of potassium, then the glucinum chloride and then another layer of potassium, and heated to fusion. The fused mass was thrown into a beaker of water; the potassium salt formed was dissolved, and there was left a dark-gray residue which when washed, dried and burnished presented a metallic luster.[4] Bussy in France prepared a similar product almost simultaneously with Wöhler, and by the same method. The product was an impure glucinum. Subsequent work by others led to the separation of a 99.8 per cent pure glucinum.

Up to the present the only methods by which the metal is extracted from its minerals are based on the obtainment of its haloids directly or by subsequent treatments, and by reducing these haloids mainly with potassium or sodium, or by electrolyzing a solution of a double chloride, bromide or fluoride of glucinum. These methods, although already employed on a quasi-industrial scale, render the cost of glucinum quite prohibitive. The direct reduction of glucina has not yet been made on a practical scale, but when this is realized the special properties of the metal, combined with its reduced cost, will contribute to its becoming one of the most valuable metals in chemical and other industries.

Uses of Glucinum

Glucinum possesses properties which will make it useful for the manufacture of special electrical and other scientific instruments and apparatus; its organic and inorganic salts have, some at least, useful pharmaceutical properties; its alloys, especially the glucinum-copper alloys, are already known to possess important properties, and their more extensive use is only a matter of lower cost. The synthetic preparation of pure precious stones for ornamental purposes, some of which have already been produced, is another field for the industrial use of glucinum and its salts.

Glucinum Minerals

The metal glucinum is not found in a native state, but is present in a great number of granitic rocks in the form of aluminates, silicates, phophates, borates, etc. The minerals of glucinum which are already known to occur in the United States in quantities sufficient to permit their economic use are:

Bertrandite. A glucinum silicate of the composition $4GlO.2SiO_2.H_2O$ (50.3 per cent SiO_2, 42.1 per cent GlO, 7.6 per cent H_2O). It is found in Bohemia, France and in the United States (Colorado, Maine, Virginia). Colorado: Mount Antero, Chaffee County; Maine: Stoneham, Oxford County; Virginia: Amelia Court House, Amelia County.

Beryl. A glucinum-aluminum silicate of the composition $3GlO.Al_2O_3.6SiO_2$ (67 per cent SiO_2, 19 per cent Al_2O_3, 14 per cent GlO). It is found in Austria, Bo-

[1] *Trans.*, Am. Inst. M. E., Vol. 31, p. 128, 1902.
[2] L. N. Vauquelin, *Ann. de Chimie et de Physique*, 1ère serie. T. 26 (1798), pp. 155-170; 170-179.
[3] Humphry Davy. *Philos. Mag.*, London, Vol. 32 (1808), pp. 1[illegible]2 and 203.
[4] F. Wöhler. *Ann. der Physik und Chemie* (Poggendorff), Vol. 13 (1828), pp. 577-582.

hemia, Brazil, Colombia, Cornwall, Island of Elba, Egypt, Finland, France, India, Ireland, Madagascar, New South Wales, Norway, Peru, Scotland, Siberia, Sweden and the United States (Alabama, California, Colorado, Connecticut, Georgia, Maine, Massachusetts, New Hampshire, New Mexico, North Carolina, Pennsylvania, South Carolina, South Dakota, Utah, Virginia).

Alabama—Near Rockford and Hissop, Coosa County.

California—Riverside County: Coahuila and near Hemet; San Diego County: Pala, Rincon, Mesa Grande, Ramona, and in the Polomar Mts. 9 miles southeast of Pala; Tuolumne County: Jamestown.

Colorado—Boulder County: near Glendale; Chaffee County: near top of Mount Antero; Clear Creek County: Georgetown; Fremont County: at East Gulch, 6½ miles north of Texas Creek; Jefferson County: near Creswell; Park County: Buffalo Mt.

Connecticut—Fairfield County: Branchville; Litchfield County: 6½ miles north of New Milford; Middlesex County: Middletown, Portland, Chatham and Haddam; New Haven County: Southford Quarry.

Georgia—Rabun County: Beck Beryl Mines, 7 miles east of Clayton.

Maine—Kennebec County: Winslow; Oxford County: Albany, Newry, Paris, Greenwood, Stoneham, Peru, Hebron (Cæsium beryl), Buckfield (Cæsium beryl); Sagadohoc County: Topsham; Androscoggin County: Auburn, Poland (Cæeium beryl); Hancock County: Catharine Hill.

Massachusetts—Worcester County: Royalston; Franklin County: Northfield; Hampden County: Blandford; Hampshire County: Chesterfield, Goshen, Norwich.

New Hampshire—Cheshire County: Sullivan, Alstead, Roxbury; Grafton County: near Orange, near Grafton[5], Wentworth, Alexandria; Merrimack County: 2 miles west of Danbury; Sullivan County: near South Acworth.

New Mexico—Santa Fé County: near Santa Fé.

North Carolina—Alexander County: near Hiddenite; Burke County: near Burkmont; Jackson County: south of Cashiers; Macon County: at head of Tennessee Creek; Mitchell County: Wiseman and other mica mines; Yancey County: Ray and other mica mines.

Pennsylvania—Chester County: near Northrop and Unionville; Delaware County: Leiperville, Chester, near Media; Philadelphia County: Fairmont Park, Germantown, Logan, Mount Airy, Shawmont.

South Carolina—Anderson County: along the Anderson Spartanburg zone.

South Dakota—Custer County; Pennington County: near Keystone.

Utah—Tooele County: about 35 miles southwest of Simpson Springs, Ibapah Mountain.

Virginia—Amelia County: Amelia mica mine; Henry County: near Axton; Rockbridge County: in Irish Creek area.

Beryllonite. A sodium-glucinum phosphate of the composition $Na_2PO_4.Gl_2P_2O_8$ (55.9 per cent P_2O_5, 19.7 per cent GlO, 24.4 per cent Na_2O). It is found in the United States at Stoneham, Oxford County, Maine.

Chrysoberyl. A glucinum-aluminum oxide of the composition $GlO.Al_2O_3$ (80.2 per cent Al_2O_3, 19.8 per cent GlO). It is found in Brazil, Ceylon, Ireland, Moravia, Siberia and the United States (Colorado, Connecticut, Maine, New Hampshire and New York).

Colorado—6 miles west of Sedalia, Fremont County.

Connecticut—Haddam, Middlesex County.

Maine—Newry and Stoneham, Oxford County.

New Hampshire—New Orange Summit, Grafton County.

New York—Greenfield, Saratoga County.

Danalite—A complex mineral of the composition $(Gl,Fe,Zn,Mn)_7Si_3O_{12}S$ with about 14 per cent GlO. It is found in the United States (Colorado, Massachusetts, New Hampshire).

Colorado—West Cheyenne Canyon, El Paso County.

Massachusetts—Essex County: Rockport, Cape Ann, Gloucester.

New Hampshire—Bartlett.

Gadolinite. A complex silicate of glucinum, iron and yttrium, of the composition $2GlO.FeO.2Y_2O_3.2SiO_2$ (23.9 per cent SiO_2, 51.8 per cent Y_2O_3, 14.3 per cent FeO, 10 per cent GlO). It is found in Greenland, Ireland, Norway, Silesia, Sweden and the United States (Arizona, Colorado, Texas).

Arizona—Mohave County: In cliffs, 30 miles south of Hackberry, and near Kingman, about 6 miles west of Chin Lee Valley and 2 to 4 miles south of the Utah line.

Colorado—Douglas County: Devil's Head Mountain; Washington County: Akron.

Texas—Burnett County; Llano County: Baringer Hill.[6]

Helvite. A complex silicate of the composition $(Mn,Fe)S.3(Gl,Mn,Fe)_2SiO_4$, with about 13.5 per cent GlO. It is found in Finland, Hungary, Norway, Saxony and the United States (near Amelia Court House, Amelia County, Virginia).

Herderite. A fluophosphate of calcium and glucinum of the composition $(CaF)GlPO_4$ (43.8 per cent P_2O_5, 15.4 per cent GlO, 34.6 per cent CaO, 5.9 per cent F). It is found in Saxony and the United States (Maine: Hebron and Stoneham[7], Oxford County, and Auburn, Androscoggin County).

Phenacite. A glucinum orthosilicate of the composition $2GlO.SiO_2$ (54.45 per cent SiO_2, 45.55 per cent GlO). It is found in the Urals (near Ekaterinsburg), France, Mexico (near Durango), Switzerland and the United States (Colorado, Maine, Virginia).

Colorado—Chaffee County: Mount Antero and Devil's Head; El Paso County: Crystal Park, 2 miles southwest of Manitou; Teller County: Topaz, Butte, near Florissant, and at Cripple Creek in the Gold King Mine.

Maine—Near Stoneham, Oxford County.

Virginia—Amelia Court House, Amelia County.

Other important glucinum minerals, which have not yet been located in the United States, are:

Euclase. A glucinum-aluminum silicate of the composition $2GlO.2SiO_2.Al_2O_3.H_2O$ (41.3 per cent SiO_2, 35.2 per cent Al_2O_3, 17.3 per cent GlO, 6.2 per cent H_2O). It is found in Brazil (Province of Minas Ceraes), Ural (Orenburg District) and in the Austrian Alps.

Eudidymite. A glucinum-sodium silicate of the composition $H_2O.Na_2O.2GlO.6SiO_2$ (73.4 per cent SiO_2, 10.2 per cent GlO, 12.7 per cent Na_2O, 3.7 per cent H_2O). It is found in southern Norway, near Langesund fiord.

[5]Here are found crystals of beryl weighing up to 2900 lb.

[6]Here are found crystals of gadolinite weighing up to 60 lb.

[7]The Stoneham mineral is also called glucinite.

Hambergite. A glucinum borate of the composition $4GlO.B_2O_3.H_2O$ (53.25 per cent GlO, 36.72 per cent B_2O_3, 10.03 per cent H_2O). It is found in southern Norway, near Langesund fiord.

Leucophane. A complex silicate of the composition $NaF.3GlO.3CaO.5SiO_2$ with 10.3 per cent GlO. It is found in the southern part of Norway, near Langesund fiord.

Meliphanite. A complex silicate, somewhat similar to leucophane, of the composition $NaF.2GlO.2CaO.3SiO_2$ with 13.1 per cent GlO. It is found in Norway, near Langesund fiord.

Trimerite. A complex silicate of the composition $(Mn,Ca)_3SiO_4.Gl_2SiO_4$ with 16.6 per cent GlO. It is found in Sweden, at Vermland.

Glucinum is also found in some natural waters, monazite sand, and some aluminous schists.

Treatment of Glucinum Minerals for Glucina

Method of Vauquelin[8]

The mineral (beryl) is crushed and heated. The cooled mass is pulverized and mixed intimately with 3 parts of its weight of caustic potash, and the mixture is fused. The mass obtained is cooled and dissolved in water; filter to separate the silica. The filtrate is treated with an excess of caustic potash solution and boiled until a precipitate is obtained which contains the hydroxides of all the glucinum and some of aluminum. The precipitate is filtered off and dissolved with hydrochloric acid and reprecipitated with potassium carbonate. This precipitate is filtered off and dissolved with sulphuric acid, and potash is added to the solution, when aluminum separates in the form of crystallized alum. Filter. The filtrate, which has a very sweet taste, is diluted with water and an excess of ammonium carbonate is added. Only the glucinum salt remains in solution. Filter. The filtrate is concentrated by boiling until a precipitate is obtained, which is washed and dried, yielding basic glucinum carbonate. This when calcined yields glucina (GlO).

Method of Debray[9]

The mineral (beryl) is pulverized and mixed with half its weight of powdered quicklime. The mixture is fused in clay crucibles. The glass obtained is powdered and treated first with dilute nitric acid, then with concentrated nitric acid, with continuous agitation till it is reduced to a homogeneous jelly. This is evaporated to dryness and calcined sufficiently to decompose the nitrates of aluminum, glucinum, iron and also a small portion of the nitrate of calcium. The residue, which consists of silica, alumina, glucina, iron sesquioxide, calcium nitrate and a little lime, is boiled with an ammonium chloride solution, when the calcium nitrate and the lime are dissolved with evolution of ammonia. (If there is no evolution of ammonia it indicates that the calcining has not been carried out sufficiently, when it is necessary to calcine again and re-treat as above.) Filter. Pour the filtrate into an excess of an ammoniacal solution of ammonium carbonate. Allow to stand for 8 days, when all the glucinum and a small amount of iron salts are dissolved. Add a little ammonium sulphide to precipitate the iron completely. Filter. The filtrate contains only the glucinum salt. Concentrate the solution by boiling, when the ammonium carbonate is decomposed with the formation of a basic glucinum carbonate which separates as a white powder precipitate. Filter. This precipitate washed, dried and calcined yields glucina.

Method of Scheffer[10]

This method is based on the fact that when metallic zinc is introduced into a solution of aluminum sulphate, zinc sulphate is formed along with basic sulphate of aluminum which precipitates. This precipitation is complete in a dilute solution. The glucinum sulphate treated in an analogous manner is decomposed with the formation of dibasic sulphate which remains completely dissolved.

The mineral (beryl) is powdered and mixed with fluorspar. The mixture is digested with sulphuric acid at a gentle heat (about 200 deg. C.) and ultimately heated to dull red to expel the silicon fluoride and the excess of sulphuric acid. The residue is dissolved in water acidulated with sulphuric acid. In order to remove the greater part of aluminum add to the solution potassium sulphate or ammonium sulphate, thus forming alums which crystallize out. Filter. The filtrate is greatly diluted, and metallic zinc is added. Allow to stand 2 to 3 days. Heat and filter. To the filtrate add a quantity of potassium sulphate proportional to the amount of zinc used (1.4 parts K_2SO_4 for 1 part Zn) to form with the sulphate of zinc a double salt which crystallizes out. To remove the rest of the zinc add to the solution an excess of sodium acetate and pass a current of hydrogen sulphide. Filter. The filtrate is treated with ammonia and ammonium sulphide to remove the iron. Filter, and neutralize the filtrate with ammonia and add an excess of ammonium carbonate. Filter and concentrate by boiling, when a precipitate will be obtained. Filter. The residue washed and dried yields the basic glucinum carbonate. This when calcined yields glucina (GlO).

Method of Gibson[11]

This method is based on the principle that ammonium-hydrogen fluoride effects the complete decomposition of beryl at a relatively low temperature, even when the mineral is only coarsely powdered. The crude ammonium-hydrogen fluoride employed is prepared by neutralizing commercial hydrofluoric acid in a leaden vessel with ammonium carbonate, then a quantity of hydrofluoric acid equal to the quantity taken in the first place is added, the solution concentrated by boiling, and on cooling the double fluoride crystallizes out.

The mineral (beryl) is coarsely ground and mixed thoroughly in a large iron pot with 6 parts of ammonium-hydrogen fluoride. The mixture is liquefied and boiled with continuous stirring until it becomes a thick mass and dense white fumes (ammonium fluosilicate) are given off. The mass is cooled, powdered roughly, boiled with water for several hours, allowed to settle and filtered. The residue is re-treated as above and filtered. Combine the filtrates, and then evaporate to dryness. The fluorides are converted into sulphates, by treating with concentrated sulphuric acid. Heat until a partial decomposition of the sulphates has taken

[8] L. N. Vauquelin. *Annales de Chimie.* T. 26 (1798), pp. 259-265.
[9] Henri Debray. *Annales de Chimie et de Physique,* 3ème serie, T. 43 (1855), pp. 5-41.
[10] G. Scheffer. *Annalen der Chemie und Pharmacie,* Vol. 33 (1859), pp. 144-147.
[11] John Gibson. *Journal* of the Chem. Soc., London, Vol. 63 (1893), pp. 909-922.

place. Digest with water and filter. Add to the filtrate nitric acid to oxidize the iron and pour the solution in small portions at a time into an excess of ammonium sesquicarbonate with frequent agitation. The aluminum salt and the bulk of the iron are precipitated and only the glucinum salt and a small quantity of iron remain in solution. Filter. To remove the last traces of iron from the filtrate add mercuric chloride and ammonium sulphide and filter. The filtrate is neutralized with ammonia and treated with an excess of ammonium carbonate. Only the glucinum salt remains in solution. (If some mercury passes over it will be eliminated in the subsequent calcining.) Filter. The filtrate is boiled until basic glucinum carbonate separates out, which is washed, dried, and ignited to yield glucina (GlO).

Methods of Lebeau[12]

The mineral (beryl) is mixed with two parts of calcium fluoride, and the mixture fused in a graphite crucible. The fused mass is poured into water, thus yielding a porous material which is easily pulverized. The powder is placed in a stoneware vessel and attacked with sulphuric acid in the cold, avoiding excessive heat. Silicon fluoride escapes. When this reaction is complete, heat on a sand bath until white fumes of sulphuric acid appear. Now throw the mass by small portions into water, when the sulphates of aluminum, glucinum and iron are dissolved, and there remains a deposit of calcium sulphate. Decant. The precipitate is washed and filtered and the solutions are concentrated. The excess of acid is then partially saturated with potassium carbonate, and the liquid is allowed to cool, when the greatest part of the aluminum separates in the form of alum. Filter. The filtrate is saturated with ammonia with the further addition of an excess of ammonium carbonate. Allow to stand for a few days with frequent stirring. Filter. The filtrate on ebullition deposits an impure glucinum-ammonium carbonate. Filter. The residue is redissolved in nitric acid. Dilute, and add a little potassium ferrocyanide, which throws down all the iron. Filter. (The last precipitation is avoided if instead of potassium ferrocyanide ammonium ferrocyanide is used and the iron separated by H_2S.) The filtrate free of iron is treated with ammonia; leave stand 3 or 4 days; the supernatant liquor is decanted and replaced by a concentrated solution of ammonium carbonate, which slowly dissolves the glucinum salt, leaving a slight white deposit of aluminum hydroxide. Filter. Boil the solution, the precipitate formed is carefully washed and dissolved in nitric acid. Evaporate to dryness and ignite. The product which is obtained is pure glucina (GlO).

Lebeau also used an electric furnace.[13] Instead of fusing a mixture of the mineral with calcium fluoride in an air furnace he melted and boiled the mineral (beryl) by the heat of an electric furnace. The finely powdered mineral is mixed with its own weight of clean coke. The mixture is heated in an electric furnace for 1½ hr. with a current of 1500 amp. Abundant vapors of pure silica are driven off, leaving a fused substance which consists of a mixture of aluminum carbide, glucinum carbide, iron silicide and carbon silicide. By subjecting the mass to weathering conditions it disintegrates. The disintegrated mass contains the aluminum and glucinum partly as hydrates and partly as carbides, which are easily attacked by acids. By using hydrofluoric acid and sulphuric acid the silica is expelled as silicon fluoride, and the residue, which consists of the sulphates of aluminum, glucinum and iron, is treated as above.

[12]P. Lebeau. *Comptes Rendus*, T. 121 (1895), pp. 641-644.
[13]P. Lebeau. *Comptes Rendus*, T. 126 (1898), pp. 1202-1205.

Method of Warren[14]

The mineral (beryl) is powdered and incorporated thoroughly with four times its weight of sodium carbonate. The mixture is fused for 3 hr. at the highest temperature of a powerful blast-furnace. Cool the melt, dissolve by supersaturated steam and an excess of hydrochloric acid. Evaporate to dryness, take up with water and filter off the silica. The filtrate is freed of its iron content and the precipitate is filtered off. The filtrate is rendered alkaline by means of an excess of sodium carbonate, and heated with an excess of gaseous sulphurous acid in which both the alumina and glucina dissolve. The solution is heated to boiling, when aluminum hydroxide is precipitated in a granular form instead of the tedious gelatinous deposit obtained when using ammonia. Filter. Add to the filtrate an excess of ammonium carbonate. The solution is concentrated by boiling, when basic glucinum carbonate separates out as a white granular powder. Filter the residue, wash, dry and calcine for glucina, or keep as carbonate for further treatment. (See page 358.)

Method of Wyrouboff[15]

In examining various compounds of glucinum, Wyrouboff has found that the oxalate $2GlC_2O_4.3K_2C_2O_4$ is only sparingly soluble; thus at 15 deg. C. 100 parts of water dissolve only 1.4 parts, and the solubility does not increase appreciably with the temperature, whereas at the same temperature the oxalates of aluminum, iron and chromium are completely soluble in only 2 to 3 parts by weight of water. He has made use of this property for a process to treat glucinum minerals for glucina.

The mineral is attacked with potassium hydrate, the silica separated in the usual way, the solution of chlorides evaporated to a small volume and treated with a concentrated solution of potassium oxalate. After a short time of standing a crystalline precipitate of oxalates is formed. Decant. The residue is treated with a small quantity of water, when only the glucinum salt remains undissolved. Filter the residues, dry and calcine to glucina, or preserve as oxalate and use as a starting product for other glucinum salts. To avoid the presence of acids during the operation, as the oxalate of glucinum is very soluble in dilute acids, it is best to neutralize the solution with an alkali after adding the potassium oxalate.

Methods of Pollok[16]

The mineral (beryl) is finely powdered and mixed with its own weight of caustic soda. The mixture is fused; the cooled mass is pulverized and treated with strong hydrochloric acid with constant stirring. The heat generated by the reaction brings the whole mass to the boiling point without the necessity of external heat. Allow to settle for one day. Decant, add more hydrochloric acid and water, and boil with steam. Allow to settle, siphon the solution and throw the silica on a linen filter and wash. Treat the whole of the solution

[14]H. N. Warren, *Chemical News*, Vol. 72 (1895), pp. 310-311.
[15]G. Wyrouboff. Bull. de la Soc. Chim. de Paris, 3ème serie, T. 27 (1902), pp. 733-734.
[16]J. H. Pollok, *Sci. Trans.* Roy. Dublin Soc., Series 2, Vol. 8 (1904), pp. 139-152.

with ammonia, re-dissolve the precipitate with hydrochloric acid and saturate the solution with hydrochloric acid gas, thus precipitating nearly all the aluminum as chloride and leaving all the glucinum and iron in solution. Filter. Concentrate the filtrate by boiling until it becomes of syrupy consistency, and add it by small quantities at a time to a saturated solution of ammonium carbonate with repeated stirring. Only the glucinum salt and a little iron remain in solution. Treat with ammonium sulphide to separate the iron, allow to stand for 2 days and filter. The filtrate free of aluminum and iron is concentrated by boiling to about half its volume, when all the glucinum is precipitated in the form of basic glucinum carbonate, which when washed, dried and calcined yields glucina.

By another method of Pollok the powdered mineral is mixed with caustic potash and fused. The cooled mass is pulverized and treated with dilute sulphuric acid and well boiled with steam. Filter to separate the silica. The filtrate is evaporated to the crystallizing point, allowed to cool and stand for one day. The alum crystals formed are drained off. Re-evaporate the filtrate and repeat the process until a portion of the mother liquor, when poured into an excess of ammonium carbonate, gives a precipitate that completely re-dissolves on shaking up. The whole of the liquors containing all the glucinum as sulphate and some impurities is poured by small quantities at a time into a saturated solution of ammonium carbonate with repeated stirring. Add ammonium sulphide to separate the iron. Filter. The filtrate containing only the glucinum salt is treated as in the first method.

By still another method of Pollok the powdered mineral is mixed with its own weight of caustic soda and fused. The cooled mass is pulverized, treated with dilute sulphuric acid and well boiled with steam. Filter to separate the silica. The filtrate is treated with ammonia, the precipitate is re-dissolved with sulphuric acid, and potassium sulphate is added to the solution. Evaporate down to the crystallizing point, and after most of the alum has crystallized out treat the solution with its own volume of alcohol, which precipitates the remainder of the alum, leaving only glucina and iron in solution. After distilling off the alcohol the iron and glucina are separated as in the first method.

Method of Parsons and Barnes[17]

The powdered mineral (beryl) is mixed with its own weight of potassium hydroxide and fused in a carborundum crucible. The fused mass is broken up, just covered with water, and concentrated sulphuric acid is added in slight excess. The now gelatinous mass is heated and broken up until fumes of sulphuric acid are given off and the whole has the appearance of a fine white powder. The residue is next treated with hot water and on evaporation most of the aluminum crystallizes out as alum. Filter to separate the silica and the formed alum. To the filtrate which contains all the glucinum together with impurities add nitric acid and boil to oxidize the iron. Neutralize with ammonia and add enough sodium carbonate crystals to saturate the solution. Warm for 24 hr. with frequent stirring, when most of the glucinum will be left in solution almost perfectly free from aluminum and from nearly all the iron. Filter. The residue is re-dissolved and re-treated as above, and all the glucinum will be found in the bicarbonate solution. Treat with ammonium sulphide to remove any dissolved iron. Filter, dilute the filtrate to 5 times its original volume and blow steam through the solution to the boiling point, when the glucinum precipitates as a fine granular basic carbonate which is easily filtered and washed. The basic carbonate thus obtained is pure save for about 2 per cent of occluded sodium salt. To remove this salt the precipitate is dissolved in hydrochloric acid, boiled to remove carbon dioxide, and treated with ammonia. Allow to settle, filter and wash with ammonium acetate solution to prevent the formation of colloidal hydroxide. The residue consists of glucinum hydroxide, which on drying and calcining yields glucina.

Method of James and Perley[18]

The mineral (gadolinite), crushed and pulverized, is treated in iron tanks with sulphuric acid, and heated until dense fumes of sulphuric acid are copiously evolved. The sulphated mineral is transferred into copper tanks, where it is stirred in a water solution. By adding the material slowly the temperature is not allowed to rise. The solution of sulphates is allowed to settle, the clear liquid is siphoned off and precipitated with a hot solution of oxalic acid. Allow to stand for 12 hr. Filter off the crystalline rare-earth oxalates and wash with boiling water. The glucinum and iron are in the filtrate, which is heated and treated with an oxidizing agent (say potassium bromate) in order to remove the excess of oxalic acid. Add ammonium hydrate followed by a concentrated solution of sodium hydroxide until the odor of ammonia is detected. Boil. The glucinum and iron are precipitated. Filter. The precipitate is treated with enough hydrochloric acid or sulphuric acid to dissolve about two-thirds of the whole, with constant stirring. This brings about the solution of all the glucinum and some iron. Filter. The residue is tested for glucinum, and if this is found, repeat the operation. The acid extract is heated to boiling and carefully precipitated with sodium hydroxide until a small amount of the filtered liquid gives a light colored precipitate with ammonium hydroxide, showing that nearly all the iron has been removed. Heat the filtrate to boiling, treat with an oxidizing agent to oxidize the iron, and precipitate with sodium hydroxide until a small amount of the liquid gives a white precipitate of hydroxide when treated with ammonia. Filter. The filtrate is treated with sodium-hydrogen sulphide to remove the last traces of iron. Filter. The glucinum is now precipitated as a basic carbonate by adding a concentrated solution of sodium carbonate to the boiling liquid. Filter. The precipitate is washed with boiling water, dried and calcined, yielding glucina.

Method of Copaux[19]

This method is based on the fact that sodium fluosilicate is decomposed at about 750 deg. C. into sodium fluoride, which fuses at about 980 deg. C., and silicon fluoride, a very active gas which at about 850 deg. C. decomposes the mineral beryl with the formation of sodium fluoglucinate and sodium fluo-aluminate, the fluoglucinate being very soluble in water and the fluo-

[17] C. L. Parsons and S. K. Barnes. *Journal* Am. Chem. Soc., Vol. 28 (1906), pp. 1589-1595. See also C. L. Parsons, "The Chemistry and Literature of Beryllium," Chemical Publishing Co., Easton, Pa., 1909.

[18] C. James and G. A. Perley, *Journal* Am. Chem. Soc., Vol. 38 (1916), pp. 875-877.

[19] H. Copaux. *Comptes Rendus*, T. 168 (March 24, 1919), pp. 610-612.

aluminate (artificial cryolite) nearly insoluble. The mineral is powdered and mixed with twice its weight of sodium fluosilicate, and the mixture is heated to 850 deg. C. The cooled mass is easily pulverized and treated with boiling water. All the fluoglucinate and only a small quantity of the fluo-aluminate are dissolved. Filter. The filtrate is treated with ammonia to transform the fluorine salts into hydroxides. Filter. The precipitate is dissolved in sulphuric acid, and the solution concentrated by boiling until white fumes of sulphuric acid appear, when it is certain that all the hydrofluoric acid has been driven off.

It is now best to treat the sulphates by any one of the methods mentioned above for the purification of the glucinum salt in a solution of sulphates.

Chemical and Electrochemical Separation of Glucinum

Method of Wöhler

As mentioned before Wöhler was the first to separate glucinum metal by reducing glucinum chloride with potassium. He has studied the product obtained and has assigned to it properties which have not been corroborated by subsequent studies on glucinum. This was due to the fact that his product was very impure.

Method of Debray[20]

Debray in 1855 separated glucinum metal by reducing glucinum chloride with sodium in a current of hydrogen. The glucina is transformed into glucinum chloride by mixing it with charcoal and oil to the consistency of a paste and by heating this paste in a retort in a current of chlorine gas, when the glucinum chloride sublimes. The chloride and the sodium are placed in two separate parts of a retort cleaned of air by a current of hydrogen. Heat until the sodium fuses and the chloride vaporizes. The current of hydrogen carries the vapors to the fused sodium, when the chloride is decomposed with the formation of a dark mass consisting of sodium chloride and metallic glucinum. The mass is cooled and treated with water, which dissolves out the sodium chloride, leaving a residue of metallic glucinum of about 85 per cent purity.

Method of Nilson and Petersson[21]

Nilson and Petersson obtained the metal by heating to bright redness a mixture of glucinum chloride with a slight excess of sodium in a hermetically closed crucible of wrought iron. The separated glucinum was partly fused into globules and partly in the form of aggregations of little prismatic crystals, which in brightness and color resembled needles of polished steel. The average analysis of these two products gave 86.94 per cent glucinum, whereas the analysis of the globules gave 94.41 per cent metallic glucinum.

Method of Krüss and Moraht[22]

Krüss and Moraht separated the glucinum by reducing potassium-glucinum fluoride with sodium. The glucina is transformed into the double fluoride by dissolving it in hydrofluoric acid, adding potassium fluoride to the concentrated solution and crystallizing out the salt repeatedly. The crystals were heated to bright redness for 30 min. with a calculated quantity of sodium in a steel crucible. The residue left, after washing with water, consisted of hexagonal crystals of glucinum and glucinum powder slightly contaminated with iron and glucinum oxide.

Method of Warren[23]

Warren has separated glucinum by electrolyzing glucinum bromide. The basic glucinum carbonate previously obtained (see page 356) is intimately mixed with an excess of lampblack and ignited out of contact with the atmosphere. The mass thus obtained is converted into glucinum bromide by the action of bromine vapors at a full red heat in a clay retort. The sublimed bromide is dissolved and reduced to metallic glucinum by an electric current of 8 amp. and 12 volts.[24]

Method of Borchers[25]

Borchers separated glucinum metal by electrolyzing potassium-ammonium-glucinum chloride. Basic glucinum carbonate, obtained by any of the methods given above, is transformed into glucinum chloride by dissolving it in hydrochloric acid with the addition of potassium chloride and the solution evaporated to dryness, giving glucinum-potassium chloride. This is mixed with ammonium chloride, and placed in an iron crucible, which also forms the cathode. The anode consists of a carbon rod. Fuse the mixture, and the glucinum is reduced by a current of 1000 amp. per sq.m. of electrode at 5 volts. It is necessary to avoid too high a temperature, otherwise a glucinum-iron alloy is formed instead of the glucinum metal.

Method of Lebeau[26]

Lebeau obtained glucinum metal by electrolyzing sodium-glucinum fluoride. He prepared the double fluoride by dissolving in hydrofluoric acid exactly calculated proportions of glucinum hydrate and sodium carbonate and evaporating to dryness. The electrolysis is carried out very conveniently in a nickel crucible, which also serves as the negative pole, the positive pole consisting of a graphite rod which will not disintegrate under the influence of the current. First melt the salt by means of a bunsen burner, then pass the current and withdraw the heat. The mass remains in fusion. Avoid a heat exceeding a very dull red, otherwise alloys of glucinum-nickel will be formed. Use a current of 6 to 7 amp. and from 35 to 40 volts. The product obtained is a non-adherent, crystalline mass, which is isolated and treated with boiling water. After prolonged washing the disintegration is complete and the residue is a powder formed entirely of rather irregular crystals of glucinum of 99.81 per cent purity.

Method of Pollok[27]

Pollok separates glucinum by reducing glucinum chloride with sodium. He obtained the chloride by mixing glucinum oxide with four times its own weight of sugar and heating the mixture to a dull red. The mixture of carbon and glucinum thus obtained is heated in a porcelain tube maintained at a bright red heat, and a steady stream of perfectly dry chlorine gas is passed over the heated mass. The chloride condenses in white silky needles beyond the red-hot zone of the

[20] *Loc. cit.* 9.

[21] L. F. Nilson and O. Petersson, *Chemical News*, Vol. 42 (1880), pp. 297-299.

[22] Gerhard Krüss and Herman Moraht, *Ber.*, Vol. 23 (1890), pp. 730-732.

[23] *Loc. cit.* 14.

[24] This metal has been worked into jewelry articles and these are now in the possession of the Ameer of Afghanistan.

[25] W. Borchers, *Z. Elektrochem.* No. 3, 1895, pp. 40-41.

[26] P. Lebeau, *Comptes Rendus*, T. 126 (1898), pp. 744-746.

[27] *Loc. cit.* 16.

tube. This chloride is reduced by sodium in a nickel crucible. Sodium is placed at the bottom, then the chloride and then another layer of sodium. Cover well and heat until the reaction is complete. The whole mass is then plunged in absolute alcohol to dissolve the excess of sodium; boil with fresh portions of absolute alcohol, and finally wash with hot water. The glucinum thus obtained is a powder which after burnishing presents a white metallic luster.

Method of Fichter and Jabloczynski[29]

Fichter and Jabloczynski have separated the metal electrolytically by the method of Lebeau; but instead of using the salt composed of 1 molecule of glucinum fluoride and 2 molecules of sodium fluoride they reversed the proportions. They claim for this modification that the separation of the metal by dissolving the difficultly soluble sodium fluoride is made much easier. They obtained the double fluoride by mixing calculated quantites of glucinum carbonate or hydroxide with sodium carbonate and treating the mixture with hydrofluoric acid. The product is dried, fused and powdered. The powder is placed in a nickel crucible which also forms the cathode, the anode being a carbon rod. The current used is 7 to 10 amp. at 15 volts. The melt after electrolysis of 2½ hr. is removed from the crucible while still hot. After cooling and finely pulverizing, the substance is thrown, a little at a time, into a large volume of water with constant stirring. The salt dissolves almost immediately, the metallic residue being left on the bottom. The deleterious effect of the hydrofluoric acid which forms during the electrolysis is counteracted by the addition from time to time of a little ammonia and by frequent renewal of the water. The residue after washing with alcohol and drying gave on analysis 92.4 per cent glucinum metal. Microscopic examination revealed particles of glucinum oxide, which were separated mechanically by centrifuging the crude metal in ethylene bromide diluted with alcohol to a specific gravity of 1.95. The oxide settled at the bottom, leaving a 98 per cent pure metal suspended in the liquid. They also advise to avoid too high a heat, as they obtained during their work alloys containing 71.39 nickel and 27.61 glucinum, and one containing 72.07 nickel and 26.93 glucinum.

Brinton[30] followed the method of Fichter and Jabloczynski, but he found rather quantitative than qualitative differences in the results.

Properties of Glucinum

Glucinum is a white malleable metal, and can be easily forged and cold rolled into sheets. It takes a high polish and scratches glass, the hardness being between 6 and 7. Specific gravity 1.64[30]; atomic weight 9.1. Its melting point is not yet known definitely. Its specific heat is the highest of any useful metal. According to Humpidge[31] the specific heat varies with the temperature up to between 400 deg. and 500 deg. C., when it becomes nearly constant, about 0.62. (See Fig. 1.) Its latent heat of fusion is abnormally high, possibly 300 calories. Its latent heat of vaporization is probably higher than that of any known element, except carbon and boron. Its electrical conductivity is as high as that of silver, and thereby higher than that of copper. So far practically nothing is known about its tensile strength or rigidity, or about how it might be strengthened by small additions of other metals. Mendeleef[32] places glucinum in the same group with magnesium, calcium, strontium and barium, and gives the following correlative proportions:

Gl : Li : : B : Gl
Gl : Mg : : Li : Na : : B : Al
Gl : Al : : Li : Mg : : B : Si
Gl : B : : B : C

Glucinum does not exhibit allotropy. It is not altered in the air, nor does it burn even when heated to redness in a current of pure oxygen, but becomes covered with a thin coat of oxide which seems to protect it from further oxidation. It is not acted upon by cold or boiling water, nor by steam even at red heat.

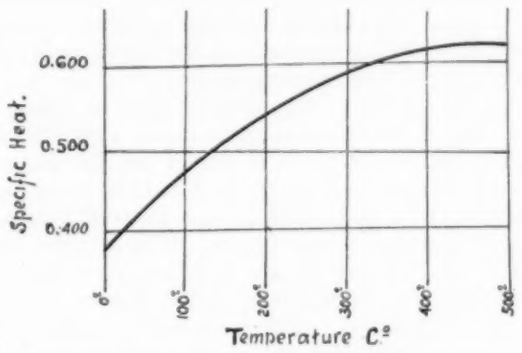


FIG. 1. CURVE SHOWING SPECIFIC HEAT OF GLUCINUM AT VARYING TEMPERATURES

When heated by an electric arc in an atmosphere of hydrogen it volatilizes without fusion and condenses to a gray metallic mirror, like arsenic. It is not attacked by sulphur even when treated with sulphur vapors. Chlorine, fluorine and bromine attack it with incandescence and form the corresponding glucinum haloids. Iodine acts more difficultly. At the heat of an electric furnace it unites readily with silicon, forming a hard brittle substance susceptible of a high polish; it also unites directly with carbon and boron, and forms many alloys with a number of metals. It is attacked with evolution of heat by hydrochloric acid gas at a temperature produced by a small alcohol lamp and with evolution of hydrogen by dilute and concentrated hydrochloric acid. It is also attacked by concentrated sulphuric acid with evolution of sulphur dioxide, and by dilute sulphuric acid with evolution of hydrogen. It is not acted upon by dilute or concentrated nitric acid at ordinary temperature and only very slowly at a boiling heat.

It is not attacked by ammonia, but dissolves readily in a potash solution. Its salts are colorless when the acids are colorless, and a large majority of them are soluble in water. The solutions have a sweet taste and give an acid reaction. In dilute acid solutions glucinum is electro-negative to magnesium and electro-positive to aluminum.

To quote again Dr. J. W. Richards:[33] "Beryllium (glucinum) is a metal which will well repay extended metallurgical research and minute physical and chemical study of its many unique properties."

[29]F. Fichter and K. Jabloczynski, *Ber.*, Vol. 46, pt. 2 (1913), pp. 1604-1611.

[30]P. H. Mallet-Prevost Brinton. Contributions to the Chemistry of Beryllium. A thesis (Univ. of Minnesota), Eschenbach Printing Co., Easton, Pa., 1916.

[31]J. W. Richards, a paper read at the Am. Inst. of Chem. Engrs., Cleveland meeting, June 14, 1916. See MET. & CHEM. ENG., July 1, 1916, pp. 26-27.

[32]W. S. Humpidge, *Proc.*, Royal Soc. of London, Vol. 39 (1886), p. 9.

[32]D. Mendeleef, *Chem. News*, Vol. 40 (1879), pp. 303-304.

[33]*Loc. cit.* 30.

Application of the Cottrell Process to the Recovery of Fume From Silver Refining Operations

Description of the Recently Installed Fume Precipitator at the United States Metals Refining Co. Works—Construction of Header Chambers, Electrode Tubes and Electrode System—Operation Control

BY W. G. SMITH* AND A. A. HEIMROD†

THE application of the Cottrell electrical precipitation processes found early recognition as a standard means of removing the suspended particles of fume from exit gases arising from copper and lead smelting operations, as well as in the recovery of of the fume from the further operation of refining the gold and silver by-products of these two major metals into commercial or marketable form.

It is the intent of this article, first, to touch briefly upon one of the earliest commercial Cottrell installations, placed in operation in one of the Eastern refineries, and, second, to describe in detail the latest developments in fume treatment by the Cottrell processes on virtually the same kind of fume. It is assumed that the readers of this article are familiar with the general principles of electrical precipitation, therefore these are not touched upon. Those, however, who wish to familiarize themselves on the terminology involved can do so by referring to the literature on the subject[1] in which will be found a very comprehensive discussion of its theory.

First Installation at the Raritan Copper Works

The first commercial installation of this kind was the Cottrell plant installed at the Raritan Copper Works, Perth Amboy, N. J., where, in September, 1913, a box type precipitator was put into operation for the recovery of values in the fumes coming from furnace operations for the refining of copper slimes. This precipitator was of the horizontal gas flow type and was built in one section, having an active length of approximately 13 ft. and an active width of 8 ft. There were thirteen sets of discharge electrodes, making thirteen aisles or passageways in parallel through which the fume and gases passed and were subjected to the high voltage discharge from the discharge electrodes. These discharge electrodes consisted of 1-in. lead strips sharpened at the edges and spaced at equal intervals on the discharge electrode supporting frame. The gases, before they entered the precipitator, were passed through a scrubber and spraying system, where some of the fume in the gases was removed and the gas temperature lowered to approximately 150 deg. F. The spraying, in addition, performed the very vital function of humidifying the gases properly for later treatment in the precipitator and ultimately the scrubbers were eliminated. The operating voltage was 40,000 volts, with a total power consumption of 3 to 4 kw. The box type treater on this problem caused considerable trouble due to building up of the fume on the collecting and discharge electrodes, and this, together with the nature and the composition of the fume, necessitated continual attention by the operator in order to keep the precipitator in service at a high point of efficiency. This precipitator was, however, operated continually until the summer of 1916, when a pipe type installation was placed in service.

Installation at the U. S. Metals Refining Plant

Since the installing of the initial electrical precipitation installation at the Raritan Copper Works, the art of precipitation of silver refinery fume has been advanced to a marked degree. The latest development along this line is the installation which has very recently been completed and placed into successful commercial operation at the plant of the United States Metals Refining Co. at Chrome, N. J.

The electrical precipitation installation on the silver refinery gases at this plant is installed at the end of a considerable length of flue system in which is also located a large settling chamber, spraying and scrubbing apparatus. The precipitator proper consists of a steel frame supporting lead top and bottom headers, connected by means of lead precipitator pipes. Three units are provided, each of which is suitable for handling approximately 4000 cu.ft. of gas per min. at 115 to 150 deg. F. at a velocity of 7 ft. per sec. through the pipes, or in case of necessity 8000 cu.ft. per min. at a velocity of 14 ft. per sec. through the pipes with only a very slight decrease in efficiency.

Each precipitator unit is 8 ft. 8 in. x 8 ft. measured from the inside of the precipitator column supports and has an overall height from foundation to the peak of the open top header of 34 feet.

Precipitator Lead Lined

All of the parts of the precipitator which come directly in contact with the gases are made entirely of the very best high grade U. S. Smelting, Refining & Mining Co. electrolytic lead, free from impurities of antimony. It has been found that the gases containing selenious and selenic acid destroy lead which contains as low as 0.1 per cent antimony, therefore no lead containing antimony was used in the construction. Any steel work that might be subjected to exposure to the gases was covered with lead in such a way that no fume could come in direct contact with the iron.

The fumes and gases from the furnaces used in the silver refinery operations are conducted into the bot-

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[1] "Problem in Smoke, Fume and Dust Abatement," F. G. Cottrell; *Smithsonian Reports*, 1913. "Recent Progress in Electrical Smoke Precipitation," F. G. Cottrell; presented before the Second Pan-American Scientific Congress, Washington, D. C., Dec. 27, 1915, to Jan. 8, 1916. "Cottrell Processes of Electrical Precipitation," Walter A. Schmidt; *Trans. Am. Inst. Chem. Eng.*, vol. 8, 1915. "The Cottrell Precipitation Process and Its Application to Foundry Dust Problems," H. D. Egbert; American Foundrymen's Association, Milwaukee, Oct. 7-11, 1918. "Treatment of Silver Furnace Fume by the Cottrell Process," C. H. Aldrich; *Trans. Am. Electrochem. Soc.*, vol. 28, September, 1915.

tom header through an inlet at each side of each unit close to the top of the bottom header chamber. Each of these inlets is provided with a liquid seal gas-tight jug damper in order to permit the shutting off of any unit and clear it entirely of gas without interfering with the operation of the remaining units, thereby giving to the whole installation flexibility and assuring continuous operation. These jug dampers are located on and supported by the top of the 2 ft. x 3 ft. rectangular bustle pipe extending along each side of the precipitator units. This bustle pipe is in turn supported by hanger rods from the main structure. (See Fig. 1.)

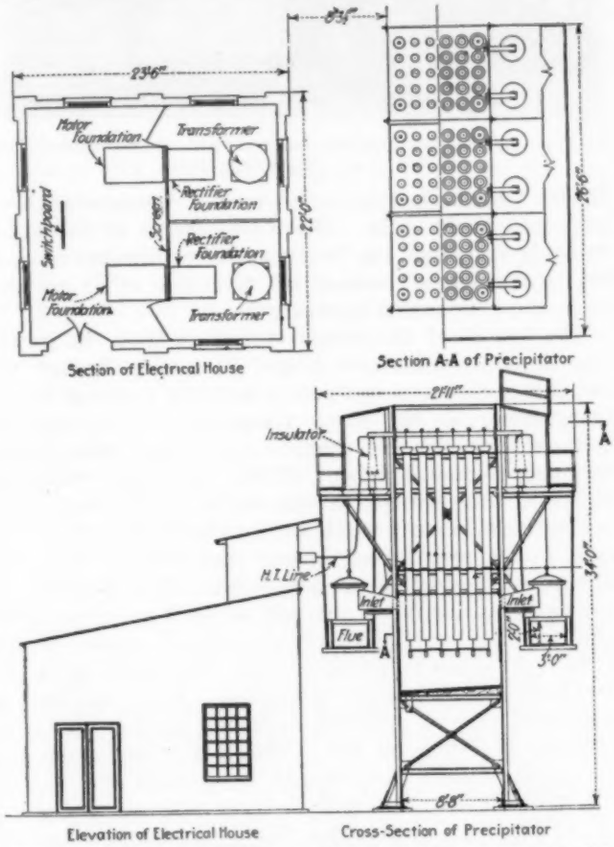


FIG. 1. CROSS-SECTIONS AND PLAN OF COTTRELL INSTALLATION, U. S. METALS REFINING CO.

The bottom header chamber is made of 8-lb. lead, the end walls being supported by lead clips fastened to the structural steel frame. In the bottom of the header box a 6-in. diameter lead drain pipe is provided in order to facilitate the flushing out of the collected precipitated material into settling tanks located alongside the precipitator. Ready accessibility to the bottom header is provided by means of doors which can be easily opened to inspect the electrode systems.

Collecting Electrode Pipes

Each precipitator unit has 30 collecting electrode pipes 16 ft. long. Twenty-six of these pipes have an internal diameter of 8-in. and the four corner pipes have an internal diameter of 11 in. The increased diameter of these corner pipes permits installing of a stiff electrode to steady the discharge electrode system and prevent it from swinging or swaying due to irregularities of gas flow or in electrical conditions. This avoids the use of insulators in the bottom header and thereby eliminates possibilities of insulator leakage trouble at this point. (See Fig. 1.)

The precipitator pipes extend into the bottom header 4 ft. The gas inlets are so arranged that the gas flows in near the top of the bottom header box, circulates around the pipes, flows down to the bottom, then up through the pipes and discharges into the top header box. This arrangement tends to break up any irregularities in the flow of the incoming gases, equalizes the gas pressure in the bottom header, tends to heat all of the pipes to a uniform temperature and thus insures proper distribution of the gas in the various pipes. The gases passing through the electrical field are cleaned and are discharged at the top of the precipitator into the top header and to atmosphere. The solid and liquid particles carried by the gas are collected on the inside surfaces of the collecting electrode pipes, from which the precipitate is periodically washed into the bottom header by means of a washing system installed in the top header. This cleaning operation is performed only on idle units, the gas temporarily being diverted to other units and the electric power line switch opened. This can readily be done, as high voltage selector switches have been installed in the electrical house whereby a precipitator unit can be put in or taken out of service without disturbing the operation of the electrical equipment or gas flow to the remaining units.

The top header of each precipitator unit is lead lined throughout and open to atmosphere at the top. The end walls of these headers have been provided with two openings to allow the high tension framework to pass through to the steel insulator compartments, where it is supported on 3-ft.-high corrugated pillar type insulators. These are properly hooded with steel hoods in order to protect the insulators from moist gas and bad weather conditions.

The installing of the collecting electrode pipes was accomplished by passing a mandrel through the pipes so as to remove any irregularities such as projections or dents. They were then passed through the lead-covered steel top header supporting plate, which was drilled to allow the pipes to pass through freely to the second steel lead-covered supporting plate 9 ft. 9 in. below the top header. After the pipes were in place they were burned to the sheet lead covering on the supporting plates and to the top plate of the lower header, thereby making the pipes hang plumb and assuring a tight joint around pipes where they enter the bottom header.

The Electrode System

The discharge electrode system of each unit consists of, first, four corrugated pillar type insulators[2], two on each side of the precipitator unit, insulating the high tension frame from ground, these insulators, as stated before, being protected against bad atmospheric conditions by means of sheet iron hoods. Second, the electrodes are made up of a star section lead-covered iron wire, carefully centered in the pipes and supported from 2-in. pipe bus bars. The corner pipes have stiff electrodes made of 1½-in. lead-covered extra heavy wrought iron pipe. Around that portion of the electrode that is in the precipitator pipe is a spiral of star section lead-covered iron wire[3] the same as used in the other pipes. Third, the electrode system is tied together at the bottom by a sway frame to the stiff corner electrodes, and on the end of each electrode in order to hold it straight in the center of the pipe is a 20-lb. lead weight.

[2]Research Catalog No. 5-J-3.
[3]Research Catalog No. 3-E-1.

Electrical Equipment

The electrical equipment for the transformation of the available power supply at 250 volts direct current to the required potential of 65,000 volts is placed in a building close to the base of the precipitator.

The supply lines run through a main line switch and fuses mounted in a steel cabinet on the wall and from this point to the switchboard. This arrangement makes it possible to disconnect entirely the main switchboard buses and all auxiliary wiring from the power supply lines.

The switchboard consists of two slate panels, each having a main and a lower section, and each controlling independently one of the duplicate sets of electrical apparatus. The lower panel sections are reserved for the motor starter face plate, manual operating handle, overload and under voltage trip coils. The main sections of each panel have mounted upon them all the control equipment except the motor starters and high tension switching devices. On each main section is a single pole circuit breaker in the motor circuit (protecting that side of the circuit not protected by the overload coil on the motor starter); a main line motor switch; a generator field switch and a field discharge resistance; a generator field rheostat operating handle (with rheostat on the back of the panel); a double pole, overload trip, under-voltage release, circuit breaker in the line from the generator to the transformer; a rheostat switch; a double pole double throw reversing switch and a transformer tap switch in this same line; and a voltmeter and an ammeter in the transformer circuit. By means of a potential plug the voltage may be measured either at the generator terminals or the transformer terminals, the difference being the voltage drop across the line rheostat (plus a small line drop).

Generator Equipment

The two motor generator sets consist of a 40-hp., 220-volt, 150-amp. motor and a 25-k.v.a., 220-volt, 113-amp. single-phase 60-cycle generator, both manufactured by the Westinghouse Electric & Manufacturing Co., and supplied to generate the alternating current. The mechanical rectifiers, directly connected to and therefore operated in synchronism with the motor generator set, were manufactured and supplied by the Research Corporation. Near the rectifiers are the high voltage transformers rated as follows: 25 k.v.a., 200 volts low tension, 75,000 / 70,000 / 65,000 / 60,000 /

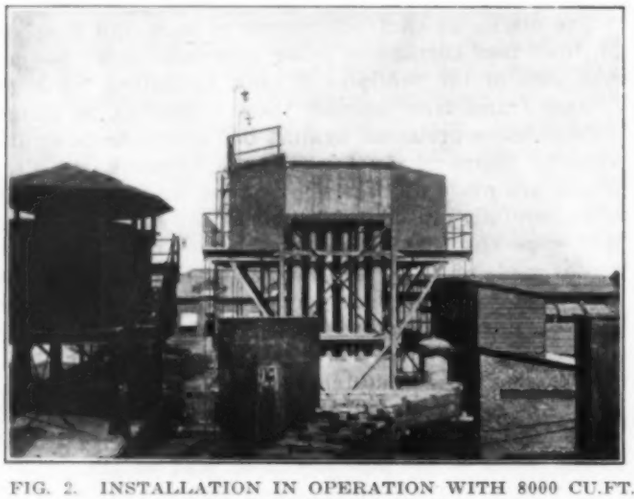


FIG. 2. INSTALLATION IN OPERATION WITH 8000 CU.FT. OF GAS, CURRENT ON

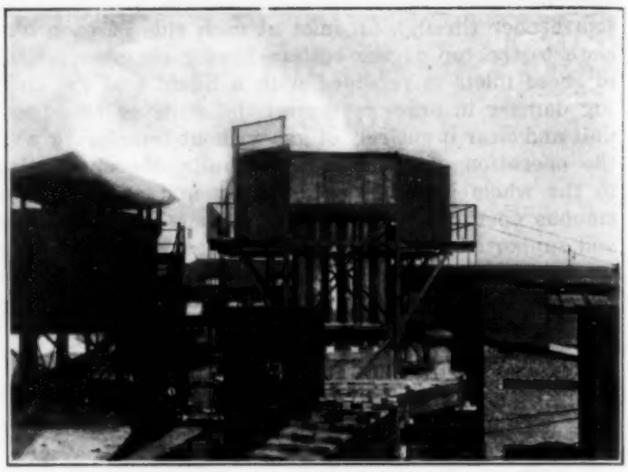


FIG. 3. INSTALLATION IN OPERATION WITH 8000 CU.FT. OF GAS, CURRENT OFF

55,000 volts high tension; 60 cycles, complete with oil gage and choke coils. The arrangement of the apparatus is such that the high-tension equipment of each set is completely screened off from the other set and from the low-tension apparatus.

The "path" of the electric power is from the generator at 220 volts, single phase, 60 cycles, through the switchboard control equipment and line rheostat to the transformer at the same frequency but at reduced voltage (line rheostat drop). The transformer "steps up" the voltage to about 65,000 volts and furnishes power at this voltage directly to the mechanical rectifier without going through any switching devices. Choke coils in the transformer circuit and resistances in the line afford protection against surges. The rectifier reverses the polarity of one-half of each complete cycle and supplies unidirectional current at about 65,000 volts to its main high-tension bus. One terminal of the rectifier is permanently grounded. Each rectifier is connected directly without switching devices to its individual high-tension bus. The three lines from the precipitator units are brought in through the wall of the building near the roof to three separate switching buses, which are so arranged that by means of a grounded mechanical remote control handle near the motor generator sets any or all of the three precipitator units may be connected to either of the main power buses. These switches can be operated with the buses alive, and the change over from one unit to another can be made in a very short time. It is good practice to reduce the voltage about 25 per cent before undertaking any high-tension switching. The high-tension switches are provided with padlocks so that a mechanic before going to work on a precipitator unit can lock the switch in an open position, take the key with him and be certain that voltage cannot be applied to the unit upon which he is working, the operator meanwhile being free to manipulate the two other precipitator units without interference.

The Precipitator and Its Operation

A fair idea of the precipitator may be obtained by examining Figs. 2 and 3, which show the end view of one unit; top header, insulator compartment, pipes, part of the bottom header, jug damper and main flue system. Part of the electrical equipment building with monitor, to hold the inlet bushings, can be readily located alongside the flue system.

Fig. 2 shows the precipitator operating at full capacity under normal operating voltage and Fig. 3 with the high-tension current shut off. The fume being very light in color, it is difficult to obtain a clear idea from the photograph of the contrast between "current on" and "current off" conditions, but careful note of the lamps on the top platform in each illustration will serve to emphasize this difference.

The precipitator operates as close to 100 per cent clearance as any one can wish for, and this condition is always maintained on account of the high values in the fume recovered. As soon as this precipitator becomes overloaded with the precipitated fume in the precipitator pipes the operator can readily detect this condition by his instruments on the switchboard and by the general operation and appearance of the spark at the rectifier. The high-tension selector switches in the electrical equipment house are then operated, to cut in the spare unit; the jug dampers on the inlets to the units are opened or closed as the case may be to put the unit into service or to take it out. The precipitate is then washed from the pipes by means of the flushing system. This operation varies, due largely to the selenium content of the fume; the higher the percentage of selenium in the precipitated fume the more often it is necessary to take a unit out of operation to clean the collecting and discharge electrodes.

The recoveries, judging from the short time the precipitator has been in operation, will be even greater than those indicated by the preliminary single pipe tests based on which appropriations for the construction of the commercial installation were readily made.

Exportation of Refined Sugar From U. S.

The suspension of the exportation of refined sugar from the United States by order of the United States Sugar Equalization Board, in order to correct local deficiencies and prevent the upward movement of local prices, lends interest to a statement compiled by the National City Bank of New York showing the exportation of refined sugar from the United States during the last fifty years. It shows that the quantity of refined sugar exported in the 5 years since the beginning of the war is more than double that of the half century preceding the war. The quantity sent out of the country in the 5 years ended with June, 1919, is in round terms, 5,000,000,000 lb., against 2,000,000,000 lb. in the half century preceding the war, and the value in the 5-yr. war period was $290,000,000, against $120,000,000 in the half century prior to the war.

The sudden demands on the United States for refined sugar which came with the beginning of the war, says the bank's statement, is due to the fact that most of the European countries which had formerly relied for their sugar upon the beet fields of Germany, Austria-Hungary and Russia found their usual supplies cut off by the war and were compelled to look to the cane sugar area of the world for supplies. The cane sugar area is chiefly Cuba, Porto Rico, Hawaii, the Philippine Islands, Java and India. Cuba and our own islands send their raw sugar to the United States to be refined; India consumes all of its sugar locally; and Java exports a large proportion of her product in the raw state to her neighbors in the Orient, especially India, Australia and Japan. The Latin-American countries, which produce about 1,000,000 tons annually, have little for exportation. This left Cuba and the islands belonging to the United States as the chief available source for cane sugar, and as all of these islands have been sending their raw products to the United States for refining, quite naturally the European countries requiring sugar turned to this country for supplies of the refined article.

As a consequence of this condition the quantity of refined sugar exported from the United States in our fiscal year 1915, the first year of the war, was 550,000,000 lb., in 1916 1,630,000,000, in 1917 1,250,000,000, in 1918 575,000,000 and in 1919 about 1,000,000,000 lb.

While export prices prior to the war were much higher than those in the period immediately preceding the war, they were materially less than those in the early part of the 50-yr. period prior to the war. The average export price of the refined sugar sent out of the United States during the war ranged from 4.7c per lb. in 1915 to about 7.1c in 1919, while the average export price in 1871 was 13.2c per lb., in 1875 10.8c, in 1880 9.0c, 1890 7.0c, 1900 4.5c, 1905 3.5c, and in the fiscal year 1914, all of which preceded the war, 3.6c.

While most of the exportation from the United States has gone to Europe, the other parts of the world are gradually turning to the United States as a new source of supply, and the exports of refined sugar in the fiscal year 1918 were: to Argentina 93,000,000 lb., Uruguay 21,000,000, Mexico 18,000,000, Canada 12,000,000, Africa 4,500,000, and to Asia (chiefly Japan and India) nearly 1,000,000 lb.

This habit of the cane sugar producers of America of sending their product to the United States to be refined grew out of the fact that the United States was the chief consumer of their product, while Europe, the other great sugar-consuming section of the world, was supplied from the beet fields, especially those of Germany, Russia, and Austria-Hungary. The United States consumed at the beginning of the present century one-fourth of the sugar of the world, but with the great enlargement of world production which followed the year 1900 the share of the world's crop consumed by us fell to about one-fifth, although the quantity consumed by us steadily increased. World production in 1900 was 19,000,000 lb., in 1910 33,000,000,000 and in 1914 42,000,000,000, and as a consequence of this tremendous increase in production, the percentage of the world's crop consumed by us fell from 25.7 per cent in 1910 to 20.9 per cent in 1914, although our consumption grew from 4,477,000,000 lb. in 1900 to 8,793,000,000 in 1914.—*Fortnightly Information Review*, Aug. 1, 1919.

Foreign Trade of France for Six Months

Imports into France for the first 6 months of 1919 were valued as follows: Food products, 3,488,837,000 francs; industrial material, 5,000,621,000 francs; manufactured articles, 3,638,745,000 francs; total, 12,128,203,000 francs.

Exports were: Food products, 249,272,000 francs; industrial materials, 382,190,000 francs; manufactured articles, 1,464,875,000 francs; postal packages, 162,147,000 francs; total, 2,258,484,000 francs.

Imports from the United States were valued at 3,774,858,000 francs; from England, 3,243,306,000 francs; and from Argentina, the next important country, 567,389,000 francs.

Exports to the United States totaled 160,492,000 francs; to England, 533,176,000 francs; and to Belgium, the next important country, 262,152,000 francs.

Notes on the Metallurgy of Wulfenite*

Source and Importance of Wulfenite—Description of Its Metallurgical Treatment, Acid Leach, Alkaline Leach, and Fusion Methods—Comparison of These Methods—Costs of Treatment—Tabulated Results

By J. P. BONARDI
Assistant Chemist, U. S. Bureau of Mines

VERY little information concerning the hydrometallurgical treatment of wulfenite ores has appeared in the technical journals. Those who have developed processes for the treatment of such ores are either working the methods behind closed doors or have patented their ideas and, as a consequence, little is generally known about the subject.

The molybdenum market at the present time is being supplied principally from the ore molybdenite, MoS_2. This has been chiefly due to the fact that there are larger deposits of this mineral than wulfenite in the United States. The advent of flotation and its adaptability to the concentration of molybdenite resulted in the United States producing, during the war, more molybdenum than any other country in the world; and it would be safe to say that nearly 90 per cent of this came from molybdenite ores. The principal working deposits of this ore are located in Colorado, at Climax and at Empire. Other deposits being worked at the present time are at Questa, New Mexico, and near Nogales, Arizona. Colorado, Arizona, New Mexico, California, Montana and Washington constitute the principal States where either molybdenite or wulfenite, or both, occur. These, as well as the minor deposits of molybdenum ores in the United States, are described by F. W. Horton.[1]

Source and Importance of Wulfenite

Until recently wulfenite ores constituted the principal source of molybdenum in this country. Horton[2] states that:

"Wulfenite ores from Arizona have supplied the larger part of the molybdenum produced in this country to 1915, and on account of the ease with which they are concentrated they should prove a strong competitor of molybdenite for markets that do not require concentrates with a high molybdenum content."

Besides the deposits occurring in Arizona, wulfenite has been reported in several scattered localities throughout the Western States of Nevada, New Mexico, Utah, California and Montana. Several of these deposits of wulfenite might be worked at a profit and would have a better chance to compete with molybdenite if sufficient information could be obtained concerning a profitable metallurgical treatment for the concentrates.

The successful concentration of wulfenite ores presents few difficulties, as the ordinary wet processes of concentration by jigs, tables and vanners, such as are used in the concentrating mills for treating lead, copper, zinc and pyrite ores, may be applied with success on wulfenite ores, which are also amenable to pneumatic separators of various types. Vanadinite and several of the lead minerals—cerussite, anglesite, galena, pyromorphite and mimetite—which oftentimes occur with wulfenite are also recovered in the wulfenite concentrates, being of practically the same specific gravity. Usually a concentrate of 15 to 20 per cent MoO_3 is the best obtainable when the above-mentioned lead minerals occur to any extent in the ore. A pure wulfenite mineral contains 39.23 per cent MoO_3 and 60.77 per cent PbO. Wulfenite buyers sometimes specify that the ore should contain a minimum of 20 per cent MoO_3, or 13.33 per cent Mo. Though the presence of other lead minerals would lower the grade of concentrates, any smelting process employed would recover the lead, which would also carry along the precious metals, gold and silver, which sometimes are found associated with the wulfenite crystals or in the lead gangue minerals. Horton[3] cites a case where gold was found as native metal in the wulfenite crystals themselves. The Mammoth mine, about 3 miles from Mammoth, at Shultz, Pinal County, Arizona, was worked originally for its free gold content. Part of the tailings from these workings later supplied 750 tons of wulfenite concentrates out of 795 tons of combined wulfenite and molybdenite concentrates that constituted the total production of this country in 1903.[4]

Purpose of Investigation

In view of the little that has been published concerning the metallurgical treatment of wulfenite ores and the difficulties connected with some of the processes used, it was deemed advisable to make a preliminary study into the metallurgical possibilities of wulfenite. Although the now known commercial deposits of wulfenite may not be able to supply the molybdenum demand even in normal times, this mineral may still prove to be a strong competitor of molybdenite in the future. Wulfenite offers some advantage over molybdenite in that any successful process for recovering molybdenum would necessarily recover the lead and any precious metals as by-products, and thus reduce the cost of treatment.

The material used consisted of wulfenite concentrates kindly furnished by the Rowley Copper Mines Co., Gila Bend, Arizona. Analysis of the concentrate gave the following results:

	Per Cent		Per Cent
MoO_3	23.77	Mo	15.85
PbO	47.93	Pb	44.53
Fe_2O_3	1.16		
Al_2O_3	1.34		
SiO_2	4.90		
V_2O_5	.74		
P_2O_5	.20	P	.08
As_2O_5	1.02	As	.66
$BaSO_4$	18.56		
Total determined	99.62		

*Published by permission of the Director of the Bureau of Mines.

[1] Horton, F. W., "Molybdenum, Its Ores and Their Concentration." Bulletin 111, Bureau of Mines, 1916.

[2] *Loc. cit.*, p. 45.

[3] *Loc. cit.*, p. 115.

[4] Pratt, J. H., "The Steel-Hardening Metals: Mineral Resources, U. S., for 1903," U. S. Geol. Survey, 1904, p. 308.

An assay for gold and silver gave respectively 0.007 and 0.293 oz. per ton of material, quantities altogether too low to justify commercial recovery. The above content of MoO_3 indicates a product containing 60.59 per cent of lead molybdate. Although the sample could have been graded up by elimination of the barium sulphate and siliceous gangue matter, this was not deemed advisable, since the molybdenum content was representative of the usual run of wulfenite concentrates. The presence of vanadium, arsenic and phosphorus and the excess of lead oxide indicated the presence of vanadinite, mimetite, pyromorphite and other lead minerals. Aside from the contained molybdenum, the material would be considered a valuable ore to smelt for its lead content alone.

Metallurgical Treatment

Any metallurgical treatment for wulfenite ores should include the recovery of the lead and precious metals besides the molybdenum. The principal methods may be classed under three general heads:

(1) An acid leach.

(2) An alkaline leach.

(3) Fusing the ore with some material that will give the lead in metallic form carrying the gold and silver, and the molybdenum as a soluble compound in the slag which can be extracted by solution methods or may be used directly in the electric furnace for the preparation of ferromolybdenum.

(1) Acid Leach Method. Treating wulfenite material with any acid or combination of acids did not offer any special advantage. Wulfenite is only soluble in acids when used in considerable excess and concentration. The cost of alkali to neutralize such a solution, in order to obtain proper conditions to precipitate the molybdenum from solution, is prohibitive. Further, lead is found in solution, or in the residue, depending upon what acid is used, and requires further treatment. Experiments conducted in this laboratory upon vanadinite concentrates which respond with acids similarly to wulfenite indicated the necessity of large excess of acids to effect complete solution and therefore considerable quantities of alkali for neutralization prior to precipitation. If an ore contains any gold or silver values, the recovery of such values with such a treatment requires further expense. In addition, the elimination of arsenic, phosphorus or other elements from solution makes this method of treatment complicated and expensive. If molybdenum is to compete with vanadium, an expensive method of ore treatment cannot be used, even though the metal vanadium has a high price at present. In view of these facts, detailed experiments were not conducted with acids, as the smelting processes, described later, offered better possibilities for recovering the lead as bullion together with any gold or silver values.

(2) Alkali Leach Method. Strong solutions of caustic or alkali carbonates will render only a very small percentage of the wulfenite soluble, so these methods of treatment were discarded. The solubility of wulfenite in hot sodium sulphide solution was first noticed by the writer during the course of sulphidizing wulfenite material previous to flotation experiments. The solubility of wulfenite in sodium sulphide is fairly complete in boiling solution, and from this solution, after the elimination of impurities, such as phosphorus and arsenic, the molybdenum can be recovered as calcium molybdate. The exact conditions necessary for precipitating molybdenum as calcium molybdate from alkali solutions will be described later in detail under fusion methods.

The sodium sulphide treatment offers an excellent method for treating wulfenite, as the lead, together with the precious metals, will be found in the residue as sulphides in a concentrated form, which can easily be shipped to the smelters for further treatment. The molybdenum goes into solution as sodium molybdate.

A method, somewhat similar, for treating vanadinite is described by G. Fester in German patent No. 294,932.[5] A description of this method is as follows:

"A V-Pb ore is finely ground and boiled, with stirring, with a solution of Na_2S, whereby the following reaction takes place: $Pb_3(VO_4)_2 + 3Na_2S = 3PbS + 2Na_3VO_4$. The resulting solution, still containing an excess of Na_2S, is saturated with fresh ore according to the counter-flow process, whereby all sulphur is taken up by the lead ore with the production of a sodium vanadate solution entirely free of sulphide, from which ammonium vanadate can be separated by means of ammonium chloride. If vanadic acid or iron vanadate is to be obtained, Cl is conducted into the hot sodium vanadate solution, until it is only weakly alkaline. By this treatment, at first small amounts of dissolved SiO_2 and Al_2O_3 are separated; secondly, the thiosulphate formed from the sulphide by oxidation is further oxidized to sulphate, and thirdly, arsenite is converted into arsenate and can be precipitated in the known manner as the ammonium magnesium double salt, together with any H_3PO_4 which may be present. From the purified solution V_2O_5 is obtained by acidifying, or iron vanadate is obtained by the addition of $FeSO_4$."

It is known that the method of treating wulfenite concentrates with sodium sulphide is now being used by at least one company in the United States. This company is now producing high-grade calcium molybdate of about 60 per cent MoO_3 content, practically free from sulphur, phosphorus and arsenic. The high-grade calcium molybdate thus produced can be used for the manufacture of ammonium molybdate, ferromolybdenum, or added directly to molten steel in the manufacture of special alloy steels.[6] The molybdenum in the calcium molybdate is easily reduced to the metal by the carbon or silicon in the steel at the temperature of the molten bath. This method of utilizing calcium molybdate has the further advantage of introducing only small impurities into the steel, but allowance must be made for the carbon used in reducing the calcium molybdate.

(3) Fusion Method. Since it is desirable to collect the lead as bullion, which requires a reducing flux in the treatment of the ore, it would be useless to try any melt which would not give reducing conditions, even though the molybdenum could be leached from the fused mass. A calcium chloride flux would react to form calcium molybdate, which would be insoluble in water. Attempts to fuse wulfenite ore with the common fluxes, such as niter cake, sodium bisulphate, sodium nitrate, sodium sulphate, calcium chloride, sodium chloride, or a combination of these chemicals with carbon, were not made therefore, except with salt.

[5] Fester, G., "Extracting Vanadium Ores by Treatment With Alkali Sulphide," *Chem. Abstr.*, vol. 12, No. 8 (1918), p. 953.

[6] Kissock, Alan, "Process of Making Alloy Steel," U. S. Patent 1,300,279, April 15, 1919.

In the fusion conducted with salt it was found that molybdenum would volatilize as the chloride, the amount depending upon the duration of treatment and the temperature. Attempts to use excess of salt and carbon, besides volatilizing some molybdenum, gave no lead button. When four parts of molybdenite ore were treated with one part of sodium chloride in a clay scorifier at 1000 deg. C. as much as 98 per cent of the molybdenum was volatilized.

Fusion Experiments With Soda Ash and Carbon

One commercial fusion method involves the use of soda ash and carbon. The lead is recovered as bullion along with any gold or silver, while the molybdenum remains in the slag as sodium molybdate. The sodium molybdate slag, if sufficiently high in molybdenum content, is used in the electric furnace in the manufacture of ferromolybdenum. The ore, soda ash and carbon are charged into a lead blast-furnace of the ordinary type, or water-jacketed, and the charge smelted to recover the lead as bullion. The proportion of fluxing material varies with the class of ore treated, but in all cases a considerable excess is necessary to insure a high recovery of the molybdenum. A similar method was used at one time for smelting vanadinite ore at Cutter, New Mexico. The method is described by Grider.[1]

In the above method it is desirable that the slag shall carry as much molybdenum as possible, with a minimum amount of alkali, on account of the corrosive action of the alkali on the linings of the furnaces used for making ferro. On account of this difficulty, the method has been more or less discontinued.

In view of these facts, it was deemed advisable, first, to determine the minimum amount of fluxing material necessary to recover completely the lead as bullion and at the same time extract the molybdenum as sodium molybdate; and, second, to recover the molybdenum from the slag as a product which when used in an electric furnace would eliminate the trouble heretofore experienced with the furnace linings.

The possibility of precipitating a molybdate as calcium molybdate having less basic properties than sodium molybdate was suggested to the writer in the fall of 1917 by Dr. R. B. Moore, superintendent of the Colorado Station. Previous to this time, in 1915-1916, attempts had been made in the laboratory of the Colorado Station to precipitate a molybdate from an alkali leach using calcium chloride, barium chloride and ferrous sulphate, but in no case was the precipitation complete; and no further attempts were made until the early spring of 1918. During the past year, working at interrupted intervals, a series of fusion experiments have been conducted, and the exact conditions for precipitating molybdenum completely as calcium molybdate have been found.

The following data represent the results of the experiments which, though performed on a small scale, are applicable to commercial conditions. Since the exact conditions for precipitating calcium molybdate have been determined, they can be applied to any sodium molybdate slag produced either by the fusion process or by the alkali sulphide leach method. Many of the standard textbooks on chemistry have mentioned the compound calcium molybdate, but the details for complete precipitation from solution are lacking.

[1] Grider, R. L., "Concentration and Smelting of Vanadium Ore." *Min. and Sci. Press*, vol. 113, No. 11 (1916), p. 389.

Several preliminary fusions were conducted using soda ash and carbon. The sample of wulfenite concentrate which has been described was crushed to pass 100 mesh, and all fusion experiments were conducted upon this material. By using a minimum charge of soda ash and carbon (0.75 soda ash, 1 ore; 0.05 carbon), the lead could be completely reduced to the metal, but in order that this should collect in a button the maintenance of a high temperature was required. This was probably too high for a lead blast-furnace, without seriously affecting the furnace lining. It was found that the molybdenum from such a fusion could be completely leached from the slag. Sodium carbonate alone has a melting-point of 849 deg. C. and, when mixed with ore in about equal proportions, a considerably higher temperature is required before the mass becomes liquid. Although soda ash can be used for smelting wulfenite to form soluble sodium molybdate, the use of salt and sodium hydroxide in combination with soda ash presents some advantages, since such a mixture requires a lower temperature to effect a fusion, and consequently gives less trouble with furnace linings. Salt, besides the above advantages, would, if successful in replacing soda ash, effect a saving in cost of chemicals. On the other hand, although caustic soda costs a little more than soda ash, the advantages gained in its lower melting-point and its efficiency in decomposing wulfenite would probably repay the additional charge over soda ash used alone.

Fusion Experiments With Soda Ash, Salt and Carbon

Table I gives in a brief form the results of the fusion experiments using soda ash, salt and carbon.

In the following runs and subsequent experiments, fusions were made in iron-spun crucibles in a small electric furnace and carried to the point where the mass became liquid. While hot, the fused mass was poured into a conical iron mold so that the lead button could be collected and weighed separately. After cooling, the fused mass was broken up, dissolved and filtered, and the filtrate made up to a volume of one liter. An aliquot portion of 10 cc. was taken for analysis and for the alkalinity tests as described later. The molybdenum was determined after making this alkaline solution acid with sulphuric acid, then passing the solution through a Jones reductor and titrating with a one-twentieth normal permanganate.

TABLE I

No. of Run	Weight of Ore, Grams	Weight of Na_2CO_3, G.	Weight of NaCl, G.	Weight of Charcoal, G.	Ratio Ore to Na_2CO_3	Ratio Ore to Flux	Extraction Mo as Sol. Sodium Molybdate	Recovery of Pb as Metal in a Button	Remarks
1	10	10	10	1	1:1	1:2.1	85.09	80.90	Metallic lead globules disseminated throughout mass.
2	10	5	20	1	:0.5	1:2.6	83.10	No button	Metallic lead globules remained in slag.
3	10	20	10	1	1:2	1:3.1	89.30	87.60	Lead globules in slag.
4	40	30	40	2	1:0.75	1:1.8	92.7	70.80	Lead globules in slag.
5	40	40	40	2	1:1	1:2.1	97.4	80.30	Lead globules in slag.
6	40	80	40	2	1:2	1:3.05	98.2	90.40	Lead globules in slag.

Fusion Experiments With Soda Ash, Caustic Soda and Carbon

In Table II the results are given for the fusion experiments using soda ash, caustic soda and carbon.

TABLE II

No. of Run	Wt. of Ore, Grams	Wt. of Na_2CO_3, G.	Wt. of NaOH, G.	Wt. of Charcoal, G.	Ratio Ore to Flux	Extraction Mo as Sol. Sodium Molybdate	Recovery of Pb as Metal in Button	Remarks
7	40	8	5	2	1:0.33	53.20	89.40	Lead reduced to metal stuck to side of crucible. Fluid.
8	40	8	10	2	1:0.50	59.60	96.90	Fluid.
9	40	8	20	2	1:0.75	96.70	98.5	This fusion and subsequent runs required lower temperature to fuse than runs 7 and 8.
10	40	8	30	2	1:1	97.80	99.0	Fluid.
11	40	8	40	2	1:1.25	99.10	96.6	Fluid.
12	40	8	40	2	1:1.25	91.05	98.9	Fluid.
13	20	20	10	1	1:1.55	93.90	97.8	Fluid.

A review of the results of the experiments as given in Table I shows that the use of sodium chloride with soda ash, although it lowered the temperature of fusion somewhat, did not indicate that it could be substituted for soda ash, as the per cent recovery of lead and molybdenum fell off in attempts to use a flux containing less than 75 per cent soda ash to ore. The lead globules do not run together so well into a button when the soda ash is decreased and the salt increased in the fluxing charge. In a run using straight salt and carbon there was no reduction of the lead to metallic form. Further, at the temperature which the fusion required, there was a loss of molybdenum, as the chloride, from the baked cake on the side of the crucible.

The use of soda ash and caustic in combination, as shown in Table II, Run 9, where the ratio of ore to combined fluxing material was 1: 0.75, gave over 95 per cent recovery of lead and molybdenum. This run was the best from the standpoint of molybdenum extracted and lead recovered, with the minimum amount of fluxing material. Runs 7 and 8 gave good recoveries of lead, indicating that the lead minerals had been decomposed, but not enough excess alkali was left over from the reaction to combine with the molybdic oxide to make the most soluble salt of sodium molybdate. Molybdic oxide combines with the requisite quantity of sodium carbonate or caustic soda to form at least six different molybdates from the normal sodium molybdate ($Na_2Mo_4.2H_2O$), the most soluble variety, to decamolybdate ($Na_2Mo_{10}O_{31}.12H_2O$), which is only slightly soluble. The least soluble is the sodium octomolybdate ($Na_2Mo_8O_{25}.4H_2O$); this compound under the proper conditions can be crystallized out of solution. As a salt of this character had no special advantage for recovering molybdenum from solution outside of its purity, no attempts were made to make use of this insoluble property of octomolybdate.

The use of a proportion of flux—less than 75 per cent of the weight of ore—could in all probability be employed on wulfenite which did not contain such a large percentage of barite as this material. As the analyses indicated, it contained 18.56 per cent $BaSO_4$ and besides requiring the presence of caustic soda as a flux, enough soda ash must be added to convert the sulphate to carbonate so that barium carbonate would be left behind with the residue and prevent barium hydroxide from going through into the filtrate. In every run made, analyses of the leached liquors containing the sodium molybdate gave no test for vanadium, iron, barium or phosphorus; and these were found left behind with the insoluble residues. Practically all the silica remained in the residue.

Precipitation of Molybdenum as Calcium Molybdate

As previously explained, the precipitation of molybdenum from an alkali leach solution as calcium molybdate offers the following advantages:

1. Under the proper conditions a complete precipitation can be made.
2. $CaMoO_4$ may be used in the manufacture of special alloy steels.
3. $CaMoO_4$ may be used in the electric furnace in manufacture of ferro-alloys.
4. $CaMoO_4$ may be used for the preparation of purified chemical salts.

The precipitation experiments on calcium molybdate were made on 100 cc. aliquot portions of solutions which were obtained from the previous fusion runs as indicated in Tables III and IV. The methods of preparing these solutions from the fusions have been previously described.

TABLE III

Precipitation With Large Excess of $CaCl_2$ Solution at Room Temperature

Leached Solution From Run No.	Mo Extracted by Leach	Grams Mo per Liter of Solution	Per Cent Mo Precipitated as $CaMoO_4$	Remarks
1	85.09	1.35	47.30	Solution stood over night before filtering.
2	83.10	1.32	49.60	Solution stood over night before filtering.
3	89.30	1.41	50.90	Solution stood over night before filtering.
12	91.05	5.96	40.03	Solution stood over night before filtering.
13	93.90	2.88	60.00	Solution stood over night before filtering.

The above figures clearly indicate that molybdenum cannot be precipitated completely at room temperature by calcium chloride solution, even if employed in large excess and allowed to stand several hours. The best precipitation found was 60 per cent, that of run No. 13, given above. To be certain that an excess of calcium chloride had been used the filtrate from the calcium molybdate precipitate was tested for the presence of calcium salts.

TABLE IV

Precipitation by Slaked Lime Emulsion at Room Temperature

Leached Solution From Run No.	Mo Extracted by Leach	Grams Mo per Liter of Solution	Per Cent Mo Precipitated as $CaMoO_4$	Remarks
5	97.4	6.:8	8.9	Excess amount of slaked lime added to bottle—shaken 6 hr.
6	98.2	6.23	7.8	Excess amount of slaked lime added to bottle—shaken 6 hr.
11	99.1	6.28	8.4	Excess amount of slaked lime added to bottle—shaken 6 hr.

As indicated above, the use of slaked lime with prolonged agitation gave at the best less than 9 per cent precipitation of molybdenum.[5] Attempts to use a

[5]Experiments performed in this laboratory for precipitating vanadium in the presence of molybdenum were successful by using slaked lime in a boiling solution. The alkalinity of the liquor was found to be increased by this treatment—a fact which assists in keeping molybdenum in solution. No special alkalinity was necessary or desirable for the precipitation of the vanadium, as some of the liquors after precipitation of the vanadium varied in alkalinity from an equivalent of 27.4 to 73.4 g. of sodium hydroxide per liter. See Conley, J. C., "A Proposed Metallurgical Process for the Treatment of Vanadinite for the Recovery of Lead and Vanadium," CHEM. & MET. ENG., vol. 20, No. 10, p. 514.

large excess of $CaOCl_2$, bleaching powder solution, at room temperature on duplicate solutions of runs 5, 6 and 11, gave respectively 73.1, 77.9 and 66.9 per cent molybdenum precipitated; indicating that the complete precipitation did not depend upon the oxidized state of the molybdenum in the leached liquors. Bromine was tried as an oxidizing agent, followed by excess calcium chloride at room temperature, without improving the results. However, on boiling these solutions the molybdenum was completely precipitated.

TABLE V

Precipitation With Excess $CaCl_2$ Followed by Boiling the Solution

Leached Solution From Run No.	Mo Extracted by Leach	Conc. of Mo per Liter	Per Cent Mo Precipitated as $CaMoO_4$	Remarks
5	97.4	6.18	99.8	Solution boiled until precipitate formed became granular.
6	98.2	6.23	98.6	Solution boiled until precipitate formed became granular.
11	99.1	6.28	97.2	Solution boiled until precipitate formed became granular.
4	92.7	5.88	98.6	Solution boiled until precipitate formed became granular.
9	96.7	6.12	98.3	Solution boiled until precipitate formed became granular.
10	97.8	6.20	95.6	Solution boiled until precipitate formed became granular.

The fact that in every one of the experiments described over 95 per cent of the molybdenum was precipitated by boiling the solution, after adding calcium chloride, clearly shows the importance of boiling, since the best precipitation, after prolonged standing at room temperature, as given in Table III was only 60 per cent. The necessary amount of calcium chloride needed for complete precipitation has been worked out and will be given in detail.

Conditions for Precipitation

The complete precipitation of molybdenum is brought about only in practically neutral solutions. That is, sufficient calcium chloride solution should be added to completely combine with all the carbonate and hydroxyl radicals in solution up to the limits of the solubilities of $CaCO_3$ and $Ca(OH)_2$, which will be precipitated along with the calcium molybdate. When this condition has been satisfied, the resulting solution will be found to be only slightly alkaline, due principally to the small amount of calcium hydroxide still in solution. When this solution has been boiled and agitated vigorously, until the precipitate has become granular in appearance, it will settle quickly and can be easily filtered and washed. Only a trace of molybdenum will be found in the filtrate.

TABLE VI

Alkalinity Tests on Fusion Leached Liquors From 40 Grams Concentrates, and Total Alkali Equivalents

Leached Solution From Run No.	Grams Na_2CO	Equivalent Grams NaOH	Equivalent Grams CaO	Grams CaO for Leached Liquor From 100 G. Concentrate, per Cent
4	27.56	20.80	14.56	36.40
9	30.74	24.20	16.24	40.60
10	41.34	31.20	21.84	54.60

The total alkalinity of leached liquors from 40 g. of wulfenite concentrate obtained in runs 4, 9 and 10 gave total alkali equivalents in grams as indicated in Table VI; the alkalinity being first determined as total Na_2O, and then calculated as the chemical equivalent Na_2CO_3, NaOH and CaO.

From several experiments made, it was found that the amount of $CaCl_2$ solution required, figured in equivalent terms to CaO, to completely precipitate the molybdenum, was only slightly more than the amount of calcium chloride necessary to combine with the hydroxyl and carbonate radicals.

The figures for $CaCl_2$ requirement for precipitating calcium molybdate in an alkaline solution are best found by calculating the strength of the $CaCl_2$ solution in terms of equivalent of CaO, and then adding enough of this solution to correspond to the amount of CaO required, as measured by alkalinity tests illustrated in Table VI, last column. If an excess of $CaCl_2$ solution is added beyond this equivalent CaO requirement, it will remain in the filtrate solution as the chloride. The filtrate from such a precipitation will be found only slightly alkaline, indicating that the alkalinity had been reduced down to the limits allowed by the solubility of calcium hydroxide, and that the molybdenum had been completely precipitated as calcium molybdate.

Grade of Product

The grade of product produced can be governed by neutralizing most of the free alkali before the addition of calcium chloride, in which case less calcium carbonate and hydroxide will be precipitated with the molybdenum. No attempts were, however, made to improve the grade of precipitate obtained, although, aside from the above suggestion, this could be further improved by ignition, which would decompose the hydrate and carbonate of calcium, leaving only calcium molybdate and calcium oxide. A composite sample from the calcium molybdate precipitates obtained in the experiments, dried at 100 deg. C., gave the following analysis:

	Per Cent
CaO	48.15
MoO_3	28.65
Mo	19.10
As	0.17
S	0.48
P	None
Si, Fe, Al	Trac
HO_2 and CO_2	Not determined

In the original concentrate the ratio of As to Mo was 4.16 to 100, while in the calcium molybdate it is 0.89 to 100, indicating that 78 per cent of the arsenic and all the phophorus had been eliminated in the leaching and precipitation steps in producing calcium molybdate.

The above grade if ignited would produce a product assaying approximately 37 per cent MoO_3. Although the presence of arsenic, phosphorus and sulphur are objectionable in ferro-alloys, the purchasers of ferro-molybdenum vary in the penalty for their presence. Some will allow 0.5 per cent total P, S and As, while others will allow only 0.2 per cent. The removal of sulphur can be accomplished by an excess lime charge. A calcium molybdate obtained from a concentrate carrying a smaller amount of barite than was contained in the material experimented on would in all probabilities carry down but a very small percentage of sulphur. Arsenic or phosphorus, if in considerable amount, can be eliminated from the alkali leach liquor as described by Fester,[9] or by adding an oxidizing agent such as NaOCl and then a magnesium salt. Further, some arsenic can be driven off in the electric furnace, and it has been stated that some can be further removed

[9] *Loc. cit.*

by a refining charge, such as ferric oxide and sodium carbonate. The details for grading up the product and eliminating the small amount of impurities can be worked out for each particular grade of ore treated.

A qualitative run made in a small electric furnace, using a charge of $CaMoO_4$, silica, iron oxide and carbon, gave very promising results. A button of ferromolybdenum was easily made which could be poured from the furnace; the odor of arsenic fumes during the run indicated some volatilization of this element. In making ferromolybdenum, molybdic oxide obtained by roasting molybdenite concentrates was used in crucibles before the introduction of the electric furnace, but the purity of such a roasted product in regard to As, P and S is often inferior to the calcium molybdate made in the foregoing experiments. Besides MoO_3, a ferromolybdenum charge is usually made up of lime, ferric oxide or iron scraps, and some reducing agent like resin, charcoal, coke or aluminum. Silica is oftentimes added for fluxing purposes, and in some cases silicon element has been used as a reducing agent. Calcium molybdate then is an ideal product, since it contains MoO_3 and CaO, which are required in the furnace charge. Ferromolybdenum is now being made directly from molybdenite in the electric furnace with carbon and a large excess of lime along with iron ore or scrap-iron, since the sulphur can be readily slagged as calcium sulphide with a charge of excess lime.

Costs of a Fusion Process

The following estimated value of products and cost of chemicals is based upon a 90 per cent recovery of lead metal and molybdenum as calcium molybdate. Although the recoveries for lead and molybdenum on Run 9, Table V, which run will be taken for the basis of calculation, represent an extraction of 96.70 per cent molybdenum and 98.50 per cent recovery of lead, the actual recoveries on a large scale would probably be less.

ESTIMATED VALUE OF PRODUCTS—BASIS ONE TON

4.53% lead, 890.6 lb. (90%), 801.5 lb. at $5 per cwt.	$ 40.08
5.85% Mo,* 317.0 lb. (90%), 285.3 lb. at $1 per lb.	285.30
Total value of products	$325.38

* Molybdenum in the final product as calcium molybdate; price for this element in crude concentrates varies from 75c. to $1 per lb. content.

COST OF CHEMICALS

400 lb. Na_2CO_3, soda ash, at $2 per cwt.	$8.00
1000 lb. NaOH, caustic soda, at $2.65 per cwt.	26.50
100 lb. coal or charcoal, best grade, at $8 per ton	.40
1605 lb. $CaCl_2$†, fused lump, at $25 per ton	20.00
Total cost of chemicals	$54.90

† 1605 lb. $CaCl_2$, equivalent to 812 lb. CaO, amount required to precipitate molybdenum from leached liquors from one ton of fused concentrates.

To the above must be added the cost of mining and milling sufficient ore to produce one ton of concentrates of the grade used in experiments. This is dependent upon so many factors and local conditions that no attempt at an estimate will be made here. Wulfenite ores have been mined and milled for their gold and silver content; consequently, in such cases, wulfenite concentrates could be cheaply produced. This has been well illustrated by the concentrates produced from the Mammoth dump. The ore from the Mammoth mine was originally treated for its free gold content, said to have been $6 to $7 per ton. The dump tailings from these treatments were later concentrated for the wulfenite alone. Horton states that the cost of concentrating wulfenite ores by wet processes is in general comparable to those of treating ores of galena, sphalerite, chalcopyrite, etc., by similar methods. No estimate can be made on the cost of treatment per ton for labor, overhead expenses, depreciation, etc., involved in a chemical plant treating such material, as these items are variable and depend upon local conditions.

It can be said, however, that the demand for molybdenum and the market price will have more to do with the future of wulfenite than any other factors. If the price paid for molybdenum does not warrant a sufficient margin of profit for the extra expense involved in smelting, extracting and recovering the molybdenum as calcium molybdate, then the wulfenite concentrates will be treated for their high lead content alone, or remain unused.

Considering the difference of $270 between the estimated value of products and the cost of chemicals for one ton of concentrates, it appears that there is sufficient margin to take care of all expenses involved in the mining, milling and metallurgical treatment.

In conclusion, the author wishes to express his appreciation and gratitude to Dr. R. B. Moore, superintendent of the Rocky Mountain Station of the U. S. Bureau of Mines, for his valuable suggestions throughout the progress of the work.

Golden, Colo.

Sheet Zinc Stencils

Rolled zinc has desirable characteristics not found in other materials used for making stencils and will have extensive commercial use. This is the gist of a statement made by William L. Muehler of the Patent Die & Stencil Works, New York City. In view of this concern's wide experience in making stencils, the opinion of its representative is regarded as important to the industry.

"Not only is zinc the only material that does not stretch and buckle in continuous use, but it has several other important advantages," says Mr. Buehler. "The oil board used up to now for stencils certainly is low in price but the cutting and making of a paper stencil involves the same skilled work as a stencil made of zinc, and while the former hardly will give 20 to 25 impressions or reproductions a zinc stencil will reproduce 10,000 copies.

"Zinc remains flat indefinitely. Another feature that recommends the use of zinc is the low cost of producing the finished stencil, this metal possessing qualities that permit stamping as many as 1000 stencils in one operation.

"When the manufacturer realizes the economy and value of zinc stencils, as compared with others, it will mean vastly increased demand for this metal. Stencils form the background of nearly every manufactured article—from laces to showcases.

"Right now negotiations are being carried on to supply Japanese producers with zinc stencils for use in stamping silk designs to replace the slower and more expensive hand methods now in vogue."

June Imports and Exports of Tungsten

Imports			Exports		
	Tungsten Bearing Ore			Tungsten and Ferrotungsten	
Countries	Tons	Value	Countries	Lb.	Value
Argentina	50	$40,000			
Chile	136	84,600			
Peru	99	50,337	Canada	48	$1,814
Japan	53	57,780	British South Africa	222	532
Total	338	$232,717	Total	270	2,346

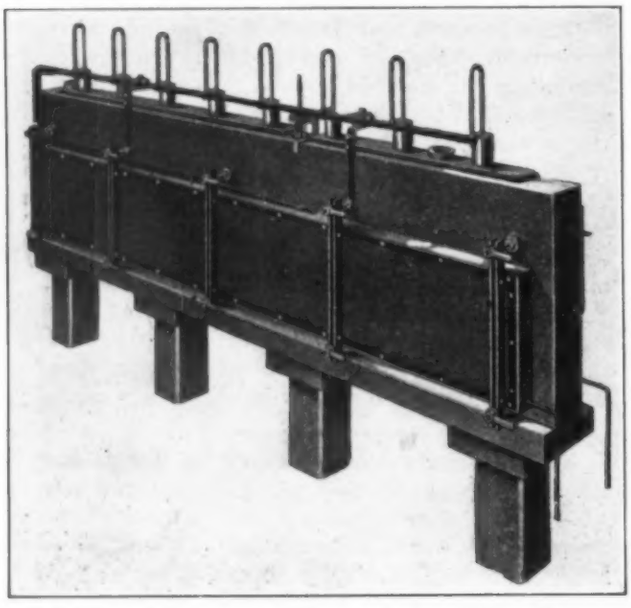
The Allen-Moore Cell in the Pulp and Paper Mill

Description of the Chlorine Bleach Department in the Paper Mill of Dill & Collins Co.—Brine, Cell, Evaporator and Bleach Room—Diaphragm Cell Construction—Summaries of Operating Reports—Present Installations

BY F. H. MITCHELL
Chief Chemist, Dill & Collins Co.

THERE is a decided tendency among progressive pulp and paper manufacturers to control so far as possible the production of their own raw materials, not merely for the purpose of the extra profit, but for the security realized in times of commercial stress and bad railroad conditions, and for securing a uniform product. Many of the large pulp and paper mills manufacture their own bleach electrolytically, not only for the reasons mentioned above, but because, added to the advantages of greater economy and security, there is the benefit of a product which is more active chemically. Many manufacturers claim actual savings in bleach consumption amounting to from 10 to 20 per cent, but the question as to whether a pound of available chlorine in a solution made from commercial bleaching powder is the equal in color produced to a pound of chlorine in electrolytic bleach liquor has been the subject of much discussion. There is, however, no question that the electrolytic bleach solution is quicker in action, and that it is possible to get a solution free from suspended lime, avoiding at the same time the losses which are incidental to getting the bleaching powder into solution. These losses are frequently more serious than is supposed. Actual tests in mills have shown losses from 2 to 20 per cent, the results varying with the quality of the bleach and the carefulness of the men.

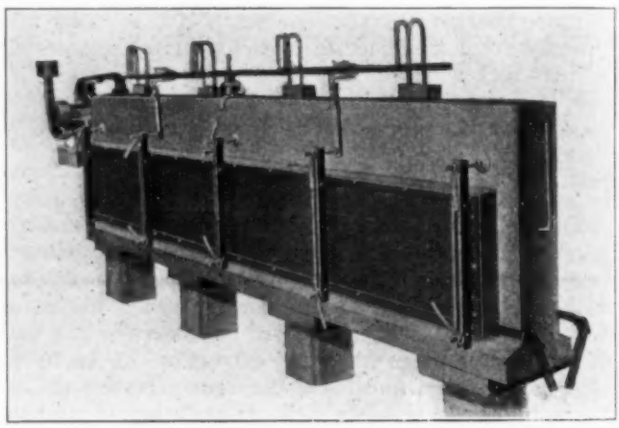
In view of this situation, it is believed that a description of the electrolytic bleach plant of the Dill & Collins Co., of Philadelphia, is of interest. Its first cell installation was started in operation on Sept. 16, 1916, and has been in steady, successful operation since that time.



ALLEN-MOORE CELL WITH ROUND LEADING-IN RODS

In consists of one series of 1200-1500-amp. Allen-Moore cells, which are operated ordinarily at a load of 1200 amp. These cells were designed by the Electron Chemical Co., and the plant and auxiliary equipment were designed by the Moulton Engineering Corporation, both of Portland, Me.

The accompanying photographs show the different parts of the plant and make detailed description unnecessary. Although but 62 cells were installed at first, a 2-story cell house was built, with a view to further



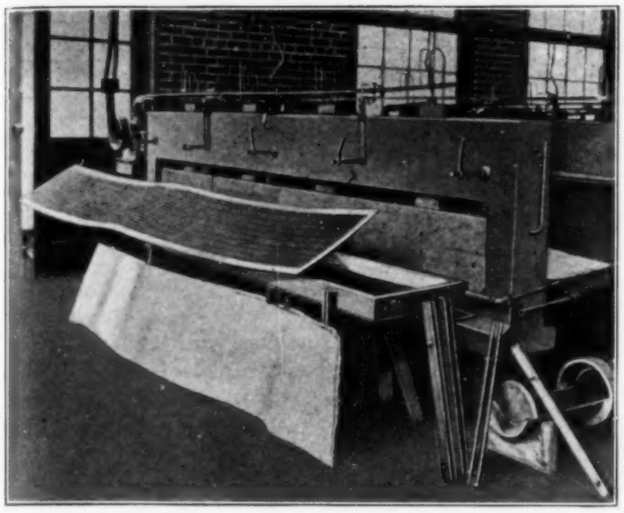
ALLEN-MOORE CELL, WITH RECTANGULAR LEADING-IN RODS

growth, and the second series of cells was installed in 1918, together with 128 cells in a separate cell house, the increase being for the Chemical Warfare Service.

The Dill & Collins bleach plant is naturally divided into the following departments: Brine room, cell room, evaporator room, bleach room and power; and for the sake of clearness these subdivisions will be considered in order.

BRINE ROOM

The first essential for the successful operation of a diaphragm cell is a brine freed not only from dirt and insoluble matter, but also from calcium and magnesium compounds. In the Dill & Collins plant the salt is carried by a conveyor to the reinforced concrete saturating column, which is kept full of salt. Water enters at the bottom and overflows at the top, the rate of flow being so regulated that a continuous flow of saturated brine issues from the top of the saturator, whence it flows by gravity to concrete purifying tanks. Here soda ash is added, with air agitation, time being allowed for the precipitation of impurities. The contents of this tank with its impurities in suspension are run through a sand filter, so constructed as to be easily washed and cleaned. The clear brine flows into storage tanks, where hydrochloric acid is added in sufficient amount to neutralize any excess of alkali. The purified brine flows by gravity



SHOWING THE EASE WITH WHICH THE DIAPHRAGM MAY BE CHANGED ON THE ALLEN-MOORE CELL

into a small flow box, the brine being kept at a constant level by a hard rubber float valve, and from this flow box the brine is fed to the cells. Each tank of purified brine holds 12 hours' supply of brine, so that little labor or close attention is required in the brine room.

A good quality of mineral salt (frequently testing 98 per cent NaCl) requires small quantities of soda ash. There is rarely sufficient magnesium present to require special treatment, and the sulphates are seldom present

CELL HOUSE NO. 1, DILL & COLLINS CO. PHILADELPHIA, PA.

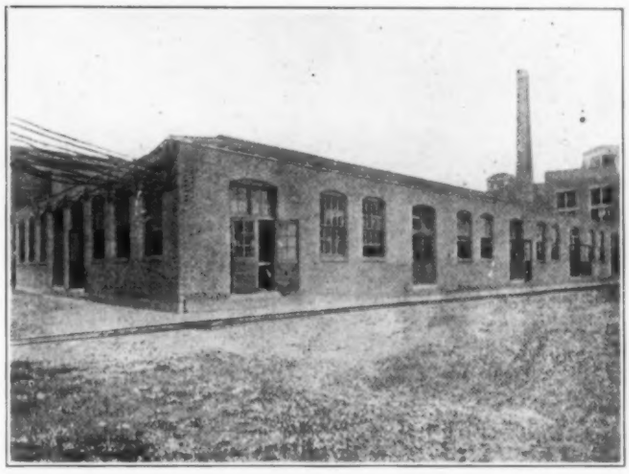
in an amount to necessitate precipitation. Careful tests are made to insure a supply of properly purified brine for the cells.

Cell Room

Each Allen-Moore cell, of which a detailed description follows, carries a float valve operated in a brine well, so that the proper level of electrolyte is maintained. By a simple device, the level can be raised as the diaphragm becomes clogged, to keep the flow at the required rate. The cells are arranged in two rows, electrically connected in series.

The caustic soda effluent flows from the front of the cells into a tile main, and the chlorine from each cell enters a tile main on which a slight vacuum is maintained by a suction fan. The hydrogen gas is discharged into the atmosphere.

The evaporator room is equipped with a double effect Zaremba evaporator, 84-in. pans, with two salt filters under the second effect. The salt caustic liquor to be evaporated contains approximately 120 g. NaOH per liter, and in the two effects is concentrated to a caustic solution of about 46 deg. B. The salt precipitated by the concentration of the liquor is caught in the filters, where it is washed to free it from caustic, and then returned to the brine system. The wash-water, collected in a storage tank, is subsequently returned to the evaporators.



CELL HOUSE NO. 2, DILL & COLLINS CO. PHILADELPHIA, PA.

The concentrated caustic, cooled to permit the deposit of any suspended salt, is used in the pulp mill for cooking the wood, or is sold in liquid form. The finished caustic liquor contains on the average 1½ per cent of salt.

Bleach Room

The tower system is used, the equipment consisting of two concrete towers, each with a partition in the middle, and a series of concrete tanks, with agitators. Each tank holds sufficient milk of lime to make the equivalent of two tons of 35 per cent bleach, in the form of a liquid carrying the equivalent of approximately 80 g. 35 per cent bleaching powder per liter.

The milk of lime in the tank is raised by a centrifugal pump to the top of the towers, down which it falls in a spray, thus absorbing chlorine, which is drawn upward by a fan. The liquor returns to the tank by gravity and is recirculated until it has reached the strength desired. In order to avoid chlorating, an excess of lime is

INTERIOR OF CELL HOUSE, ILLUSTRATING ARRANGEMENT OF CELLS

SECOND INSTALLATION DILL & COLLINS CO.

maintained at all times. When one tank is finished, a second tank of milk of lime is cut in, and the first tank is allowed to settle. After the clear bleach liquor has been decanted to the pulp mill, fresh lime is added to the empty tank and it is ready for a second run. At intervals of ten days or two weeks, depending on the purity of the lime used, the sludge from each tank is washed into the sludge tank, and the residue, consisting of silicates and other insoluble matter, is thrown away.

It is important that the lime be as free as possible from magnesium, since otherwise the bleach will not settle quickly, and it will become increasingly difficult to recirculate the residue. The chlorine apparently does not combine with magnesium until after the calcium has been used up, with the result that there is an accumulation of magnesium which proves disastrous to the keeping qualities of the bleach and to the efficiency of the process. A particularly careful study of the effects of magnesium compounds, as well as iron and manganese, was made by Messrs. Martin Griffin and John Hedalen, the results having been published in the *Journal of the Society of Chemical Industry*, May 31, 1915.

In this installation the current for electrolysis is furnished by generators direct connected to reciprocating engines, and the layout does not call for special description.

Development of Allen-Moore Cell

On account of the interest created by the operation of the Allen-Moore cell, a full description of its development and operation follows:

The Allen-Moore cell is not new, for its inception dates back to 1895, when Hugh K. Moore and Edward A. Allen were co-workers in the first commercial electrochemical plant in the United States, established in Rumford, Me., after the plans of Ernest LeSueur and Charles N. Waite. Indeed, this plant was the starting point of the development of the electrolysis of salt, and most diaphragm cells can be traced to this beginning. The story of the trials experienced in this plant is intensely interesting and should some day be told.

Besides Moore and Allen, above mentioned, were other men whose names have become well known in connection with electrolytic cells. Among them were MacDonald, Barton and others who have been responsible for a great deal of the development which has been made, and the results of the work of the four men above mentioned is seen in practically every diaphragm cell now in successful operation.

The first installation of the Allen-Moore cell in its present form was completed in May, 1912, in the pulp mill of the Jessup & Moore Paper Co., Wilmington, Del., and the plant has been in steady successful operation ever since. The Jessup & Moore Paper Co. made a second installation in 1916, in its mill at Elkton, Maryland.

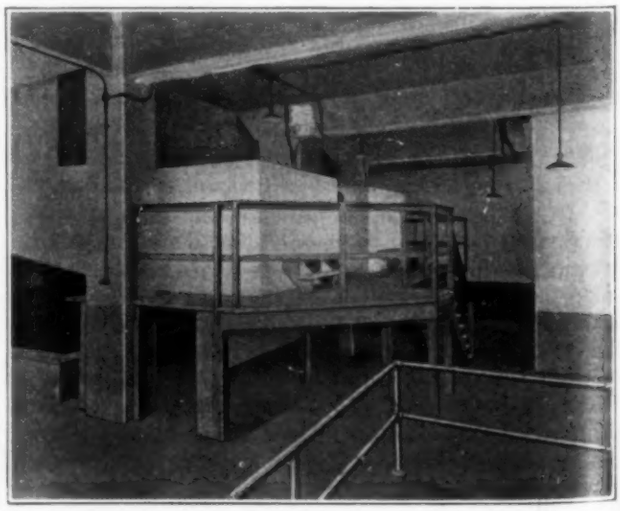
Construction of Cell

The Allen-Moore cell is a porous diaphragm cell with one face only of each diaphragm in contact with the electrolyte and was the first cell to adopt this principle.

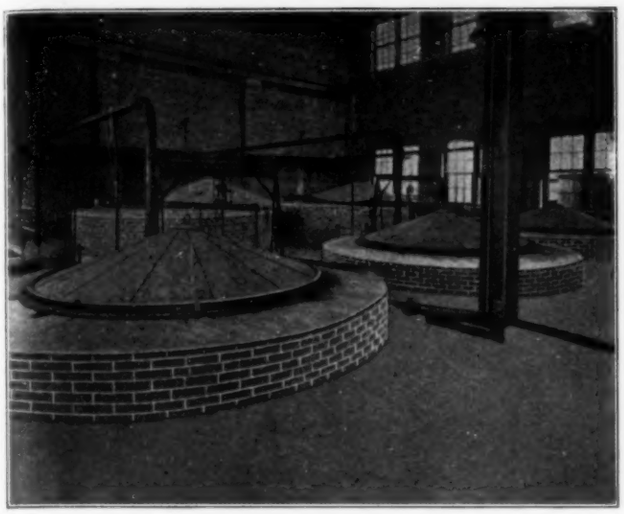
Referring to the illustration, it will be noted that the Allen-Moore cell consists of a rectangular frame of carefully placed reinforced concrete, formed by a base, two ends, and a chamber at the top, this latter being formed by the two side walls, the cell cover, and that portion of the cell ends between the side walls.

It should be realized that this reinforced concrete body serves as an insulating medium to separate the product of the anode compartment from the cathode compartment, and experience has shown that it has decided advantages. It is easily cast and it is so cheap that the total yearly cost is a very small item per ton of products. Moreover, the construction permits the accessibility which is one of the features of the cell, and is one of the factors in the high operating efficiency. The concrete bodies in the Dill & Collins plant are in excellent condition today, after being in constant use for nearly three years.

The arrangement of base, ends and chamber forms an opening in the cell body which, when closed on each side by the diaphragms and cathode chambers, constitutes the space for the electrolyte and the cell anodes. These graphite anodes are disposed in this space in such a manner that their active surfaces oppose the surfaces of the diaphragms which, backed by perforated cathode plates, cover the openings in the cell body. The arrangement of anodes, diaphragms and cathode plates is such that the asbestos diaphragms lie against the cathode plates, while between the diaphragms and active anode surfaces there is a clearance of approximately one-half inch. The electrolyte of saturated brine fills



CONCRETE BRINE TANKS



CAUSTIC POTS

this space between the anodes and diaphragms and covers the anode plates. The anodes extend through the electrolyte chamber, through the gas chamber at the top of the cell and the cell cover, and they are connected to the copper bus bar running along the top of the cell.

The brine is admitted to the anode compartment of the cell from the iron brine main through wrought iron pipes, which are connected with a hard rubber float valve which automatically controls the level of the brine in the well located in the center of each cell and maintains a constant level in the anode chamber.

The brine in the anode chamber comes in contact with the immersed graphite anode and one face of each asbestos diaphragm, of which there are two, one on each side of the anode chamber. The chlorine gas generated in the anode chamber is discharged from each cell into the tile chlorine main at the rear of each bank of cells by means of a tile U with luted connections on both the cell and the chlorine main.

TABLE I—DAILY SUMMARY

24 Hr. Ending at 7 A.M., Jan. 18, 1917

Number of cells running		53
Average voltage at switchboard		200
Average amperes		1,200
Deliveries to Mill:		Total
Pounds, 35 per cent bleach		10,997
Pounds of caustic soda		4,520
Chemical Tests:		
Grams total chlorine per 1,000 cc.		
Grams 35 per cent bleach per 1,000 cc.		84.15
Grams free lime		1.72
	Grams per 1,000 cc.	
Caustic Soda:	NaOH	NaCl
Effluent from cells	140	163.
Finished product	713	17.52
Efficiencies:		
Current efficiency, per cent		94.05
Decomposition efficiency, per cent		55.75
E.h.p. per ton of bleach		58.60
Per cent salt recovered		

The brine, percolating through the permeable asbestos diaphragms, which are supported against each open side of the cell body by means of perforated wrought iron cathode plates, is decomposed and flows down the face of the cathode plates into the channel trough of the steel frame cathode box and deposited there in the form of a salt caustic solution containing about 12 per cent salt and 8 to 10 per cent caustic soda.

As typical of the operation of the cells, a copy of a daily summary of plant operation (Jan. 18, 1917), showing the data kept is given in Table I.

On Feb. 2, 1917, after the plant had been in operation since the preceding September, an official 24-hr. test run was made. Each cell was tested for voltage and current efficiency at 6-hr. intervals, with the following average results:

0.	Cells in operation	54
1.	Active cathode area, sq.ft.	24.12
2.	Amperes per cell, average	1,200
3.	Voltage drop on individual cells (average)	3.6
4.	Current efficiency based on four tests at 6-hr. intervals, on each cell	95.3
5.	Caustic soda per cell, lb.	91.7
6.	Voltage drop on cell circuit	202
7.	Saturation of electrolyte, grams NaCl per liter	305
8.	Decomposition efficiency, per cent	55.3

It is of added interest to note that other installations of the Allen-Moore cell are operating with similar good results. Five different plants were the subject of tests not long ago, and the summary of their tests is given in Table II.

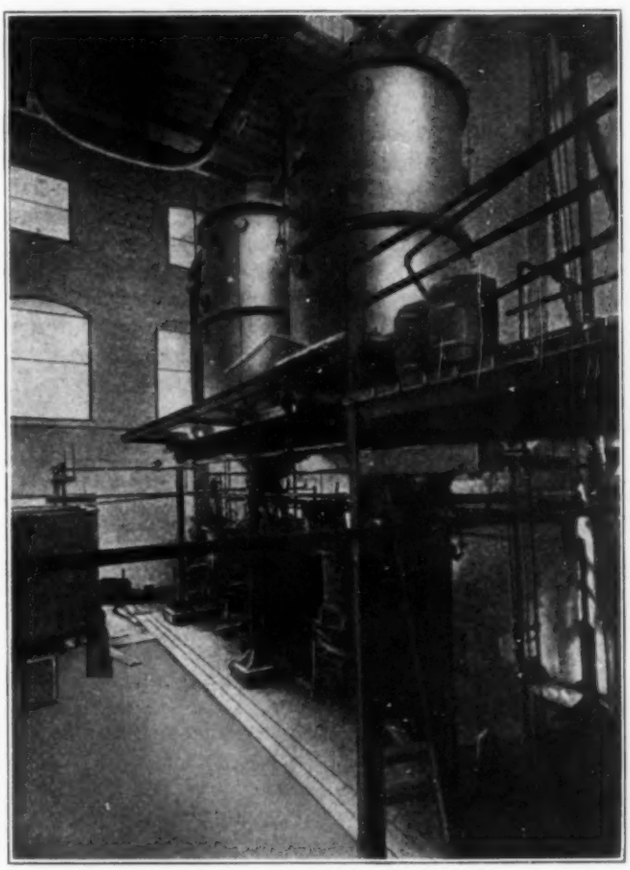
The energy efficiencies in the last column of Table II are derived in the following manner (illustration taken from the data of Plant No. 5):

$$\frac{2.3 \text{ (theoretical voltage)} \times .96 \text{ (current efficiency)} \times 100}{3.7 \text{ (actual voltage)}} = 59.6 \textit{ total} \text{ energy efficiency}$$

It will be noted that, in compiling the results of the tests, a distinction is made between voltage efficiency and total energy efficiency.

The actual average power required for producing 1 lb. of chlorine in the five separate plants considered is, therefore, 1292 kw.-hr.; derived in the following manner:

1344.2 (average amperes) × 0.00290 (lb. theoret-



DOUBLE EFFECT EVAPORATOR WITH SALT FILTERS

ical chlorine per ampere hour) × 0.9477 (average current efficiency) = 3.9 lb. chlorine per cell each hour.

1344.2 amperes × 3.55 average voltage per cell = 4.77 kw.

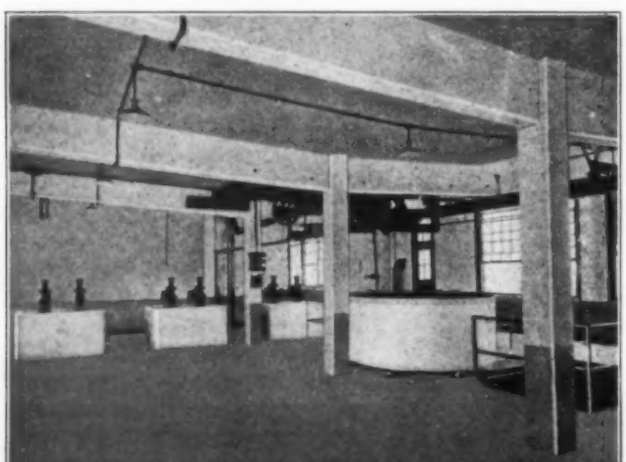
4.77 kw. ÷ 3.9 lb. = 1.292 kw.-hr. per lb. of chlorine.

TABLE II—PLANT TESTS UNDER ACTUAL COMMERCIAL CONDITIONS

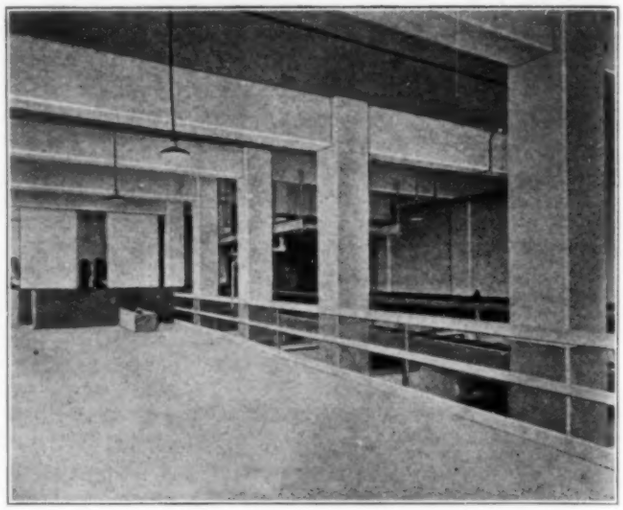
	No. Cells	Average Amp.	Average S. B. Volt.	Voltage Efficiency	Current efficiency per cent	Energy efficiency per cent	Notes
Plant No. 1	31	1362	3.32	69.27	95.00	65.8	Official — Tests run about one month after cells were put in operation.
	31	1226	3.33	69.06	96.47	66.5	
	31	1367	3.45	66.66	94.50	65.0	
	31	1112	3.20	71.87	94.22	67.7	
	31	1308	3.44	66.86	94.10	62.9	
Plant No. 2	21	1606	3.85	59.74	93.07	55.5	Official — Cells in operation about six months—21 tested.
Plant No. 2	64	1320	3.80	60.52	93.18	56.4	Unofficial — Some cells set up with carbon and some with graphite.
Plant No. 3	62	1220	3.60	63.88	95.30	60.8	Official — In operation about six months. Specified set-up.
Plant No. 4	29	1410	3.48	66.07	97.60	64.5	Official—32 cells in operation.
Plant No. 4	30	1400	3.67	62.67	93.00	58.3	Figured from actual bleach production and includes absorption losses, etc.
Plant No. 5	63	1400	3.80	60.52	94.80	57.3	Average of seven months' plant operation.
Plant No. 5	70	1400	3.70	62.16	96.00	59.6	General average of operation over period of five years.
Average...	..	1344.2	3.55	64.94	94.77	61.69	

Products Are Exceedingly Pure

It is obvious to those acquainted with the electrolytic chlorine industry that the products of the Allen-Moore cell must be exceedingly pure. The high current efficiency is sufficient proof of that. The chlorine is entirely free from hydrogen, and contains merely air and small amounts of CO_2. The purity of the caustic is best attested by the long life of evaporator tubes, different



TOPS OF GAS ABSORPTION TOWERS AND LIME-MIXING PLANT MAKING BLEACH LIQUOR



BASE OF GAS ABSORPTION TOWERS

effects frequently running more than two years without replacing a tube, and the fact that the caustic is almost entirely prevented from entering the anode compartment is proved from the fact that the anodes, operated at 1200 amp., have an average life of 18 months.

The voltages in the column illustrate the effect of different loads. At 1200 amp., with new diaphragms and new anodes, the voltage is approximately 3.3, increasing slowly to 3.5 or 3.6, when the diaphragm becomes plugged. The maximum voltage under this load is reached at 18 months, when the anodes require replacing. This maximum voltage averages 3.8. Each time the diaphragms are changed the voltage drops. After the first change, at the end of 3 months, the voltage will be nearly the same as with the new cell, but with subsequent change, as the anode wears, and the electrode distance increases, the initial voltage is higher until, at the end of the graphite cycle, a maximum voltage of 3.8 is reached.

A diaphragm life of much longer than three months can be realized, but with a loss of output per kw.-hr. The diaphragm change and the washing of the cell can be accomplished with so little labor (the regular cell attendants taking care of changes) that the increased output makes the use of more asbestos profitable.

The economical operating load of this cell naturally varies with local conditions and with power cost. It will yield almost equally good results in output over a range of from 900 amp. to 1500 amp. In fact recently, in a test at one installation, cells were operated for a period of 6 weeks at loads varying from 1500 to 1900 amp., at a voltage of 4.5, and with a current efficiency of from 90 to 92 per cent.

Bleach Installations

It is evident from the results secured in the Dill & Collins Co. plant and in others where this type of cell is used, as well as in pulp and paper mills where other types of cells are in successful operation, that the electrolytic manufacture of bleach has long since passed the experimental stage. There is no guesswork as to what a cell or the auxiliary equipment will do. Given definite premises as to cost of power, raw materials and labor, it is possible to fix the production cost of bleach and caustic soda just as accurately as the cost of pulp can be figured.

Following is a list of the pulp and paper mills producing their own bleach:

Mill:	Type of Cell Used
D. M. Bare Paper Co., Roaring Springs, Pa.	MacDonald
Brown Co., Berlin, N. H.	Allen-Moore and Burgess
Champion Fibre Co., Canton, N. C.	Wheeler
Dill & Collins Co., Philadelphia, Pa.	Allen-Moore
Eastern Electrochemical Co., South Brewer, Maine.	Allen-Moore
Hammerschlag Manufacturing Co., Garfield, N. J.	Nelson
The Jessup & Moore Paper Co., Wilmington, Del.	Allen-Moore
The Jessup & Moore Paper Co., Elkton, Md.	Allen-Moore
Kimberley & Clark, Neenah, Wis.	Wheeler
The Miami Paper Co., West Carrollton, Ohio.	Allen-Moore
New York & Pennsylvania Co., Johnsonburg, Pa.	Hargreave-Bird
Oxford Paper Co., Rumford, Maine	Whiting (mercury)
Penobscot Chemical Fibre Co., Great Works, Maine.	Larchar
Riordan Pulp & Paper Co., Ltd., Merritton, Ontario.	Allen-Moore
S. D. Warren & Co., Cumberland Mills, Maine.	Allen-Moore
West Virginia Pulp & Paper Co., Covington, Va.	Hargreave-Bird

Americanization Work in Newark, N. J.

THE sculptor Rodin was a good deal of a prophet. Most of us know his statue "The Thinker"—which is not a white-bearded old man resembling the Rev. Lyman Abbott at all. This thinker is young, he is nearly all muscle and brawn; his brow is low, and he has never thought before. But he is thinking, is thinking now, and he is thinking very hard. With all the world a-quiver with emotion, and history that none of us can understand seething in the making, in the melting-pot before us, everybody tries to think—and the man of muscle and brawn is no exception. He is trying his best, but it is not at all certain whether he will think right or wrong—with the general welfare in view, or toward the red riot of calamity as an end. He will, however, think very much as he is led. The mere presence of a leader may be a determining factor. If, then, the only one present is an I. W. W. organizer, the thinker is likely to follow him, and in the end to range himself among the powers of evil and against all government and order. But if there is any one present to teach him the ideals and ways of American citizenship, the chances are that he will follow such a leader by preference, because most men prefer law and order to chaos. On the other hand, he will not follow any leader who is not in earnest for reasons that are too obvious to need exposition.

Newark's Industrial East Side

The manufacturers of Newark, N. J.—or some of them—have grasped this fact, and, being men of imagination, they have become alive to its significance. Now the purpose of this paper is to tell what has happened in the industrial east side of the city which contains a great many chemical works and a shipbuilding yard which alone employs some 15,000 men. The phenomenon is not peculiar to Newark; doubtless other places have done as well, and some may have done better. But Newark is near by, it is in earnest, and we feel related to it by many ties of chemistry. So let us discuss Newark.

The so-called Ironbound District extends from the Pennsylvania Railroad tracks to the shore of Newark Bay. It covers about three square miles, and some 203 industrial establishments are housed within its boundaries. These employ about 40,000 persons. The total population is 62,189, while those of foreign birth and their children constitute 50,392. There were, according to the last census, 11,807 foreign-born males of voting age, of whom only 3048 had been naturalized. And there were 4588 illiterates of 10 years and over.

In regard to the people who live and work in the Ironbound District, up to a year ago nobody had been very much interested in them. They were not fashionable, nor were they picturesque. Nevertheless, they went right on living, and increasing, and multiplying. And when the thinker of the Ironbound District put his hand over his head and began to think, he was reached by the following organizations:

Influence of Various Organizations

His church and his priest. The purpose of these is to hold him to ethical standards, which is a good thing. The hold, however, is often frail.

The yellow newspapers. These preach the gospel of hate and discontent, usually with a political end in view, or to enlarge their circulation. They prepare the way for I. W. W. propaganda.

The labor unions. With their present passion to unionize everybody and everything, the labor unions have loosened up in their discussion of ideals of betterment, and have substituted problems in economics for consideration among their members in the place of problems in the art of living. This is of no help to the man who is not advanced beyond the stage of elementary thought; in fact it is more likely to upset him than to aid him. It is a great mistake to neglect the art of living as of first consideration, because the subject of economics will begin to manifest itself as soon as proficiency in the art of living has been attained.

Radicals Preach Revolution

The I. W. W. and the Left Wing Socialists tell the thinker that he is the slave of Capitalism; that the world is divided into two great hostile camps, of which one gets the rich proceeds of all the harvests and growth, while the other gets only the poor leavin's; and that it is only by a mere fiction of possession that the rich hold their property. The gospel is preached that the only way for the poor man of today to achieve abundance is by revolution; by a regular invasion of the lands and estates of the minority rich by the majority poor. The methods are very much the same, whether expounded by Left Wing Socialists, I. W. W., Bolsheviki, or any other section of the angelic choir; the main differences have to do with who shall lead the crowd, and who shall divide the swag.

There's no profit in getting excited over it. A better way of understanding it is to imagine what we should do—we and our friends—if we were Esthonians or Jugoslavs or Transylvanians, with a language of which the native-born Americans are grossly ignorant. Suppose we worked by the day in the Ironbound District, and that we had difficulty in learning this amazing English language with its ridiculous and impossible pronunciation. Supposing practically nobody on the continent except people from back home could talk to us. Suppose we had no decent books or papers, and were restricted to a pathetic little weakly weekly newspaper, printed in our own language as much for those who can't read as for those who can. We should know only the ugly side of the town, and the chances are we should show only the ugly side of ourselves.

Newark Manufacturers Take Action

It was in October, 1918, that Newark seemed ripe for propaganda and the brotherhood in Russia went so far as to send a number of their slumbering not nor

sleeping Bolshevik organizers to establish headquarters right in the Ironbound District, where a large number of Russians live. And it was then that a number of Newark manufacturers got together. It is not recorded who said what, or just who made the next move, but the fact is there was soon developed and organized a concern which is known as "The Ironbound Community and Industrial Branch of the Y. M. C. A. of Newark." The organization has its own officers, and it minds its own business. It gives the impression of being free from that element of the Y. M. C. A. which is addicted to white lawn ties and to prayer meetings and revivals. Mr. A. V. Hamburg of the Hamburg Button Co. is president. Associated with him on the executive board are Messrs. J. H. Bacheller of the Ironbound Trust Co. and F. W. Volk of J. H. Ladew Co. Of the committee of management Mr. Volk is chairman. The vice-chairman is Mr. Eugene Merz of Heller & Merz Co.; Ex-Senator J. H. Bacheller is treasurer; John Campbell of Maher-Flockhart Co. is secretary, while the other members are Messrs. Joseph Doyle of W. S. Rockwell Co., S. C. Coey of Celluloid Co. and W. F. Mullin. A number of these names will probably be familiar to many of our readers. Mr. Edward B. Jacobson, 203 Essex Building, Newark, is the executive secretary. He is an alumnus of the University of Nebraska and of the School of Civics and Philanthropy of Chicago. He has been engaged in social and welfare work for several years in Chicago Stock Yards, in Pittsburgh, and with the du Ponts.

The next step was to organize, which was easy since these men of business wanted to. They didn't want to raise a little Russia right there in Newark; and while they are nearly all ambitious manufacturers they did not want to add *bad Americans* to their products.

Meetings Held in Factories

Mr. Jacobson secured from the Prudential Life Insurance Co. and the New Jersey Law School some thirty young men who were soon trained to teach English and citizenship. They were volunteers, and they bit right into the work. Another thing was to visit the priests of the various foreign-language churches, mostly of the Roman and Greek Catholic persuasion, and these, to a man, were hearty in their co-operation. At this time Mr. R. I. Vail, who has had some fourteen years of experience in Americanization work, was added to the supervisory staff. Then meetings began all over—in factories, sometimes as part of the lunch hour, and sometimes after closing; sometimes on paid time, and sometimes on the men's own time; they work it every way, but principally in two directions: teaching English through the Peter Roberts system, and citizenship. The English classes go right on, with new ones forming constantly. In the meantime various foremen in factories have taken the teaching course, and they are now teaching also. The citizenship meetings, classes and lectures disclosed the remarkable phenomenon that Bolshevism, I. W. W. propaganda and the like were the only ideas that theretofore had been propounded. The idea of representative government appealed to them as soon as they could understand, and the appeal of revolutionary ideas lost force as soon as others were placed in competition. To those who love system and order the appeal of revolution and disorder is not strong.

Illustrated talks on government were introduced, and these have been carried on in various languages. Open forums are held, and at one of them lately, attended by 600 Russians, the speaker of the evening, who had recently returned from Russia, was invited to come again, to explain more fully the differences between the American ideals of democracy and those of the Russian Bolshevists. Within the short time the work has been under way over 630 men have been aided in getting out their naturalization papers.

Grand Pageant on Memorial Day

Then on Memorial Day there was a grand pageant in which 10,000 people participated in East Side Park. There was a Parade of All Nations to Four Corners and back, and a silver loving cup given to the best appearing division. There were tableaux, and pledging allegiance to the flag, an address by the Mayor, and folk dances, with a silver loving cup as prize for the best dancers. Then followed addresses in English, Russian, Polish, Italian, Lithuanian and Czechoslovakian. That may not sound important, but in point of fact it was so; it was the first participation of those new citizens in a public affair. It had more meaning in it than any other Decoration Day parade that we know of.

It was the privilege of the writer to visit two classes in English at the Heller & Merz works. They began after the evening whistle blew, were held on men's time, and the energy and enthusiasm of the pupils were no less than inspiring. We need not be afraid of such men. They are workers, not idlers. The loose-lipped pervert and the swaggering high-class idiot were not among them. We may well welcome them as citizens. Their situation, however, is difficult. They do not yet know the language of the country, nor are they familiar with its customs. Few of them know anybody who has got rich, except by sight. Heretofore nobody has been interested in them except their own little group, and it has been difficult to determine where to seek good advice, or to know which advice was meant for the recipient's good, and which for the adviser's own profit. In the old days things were different, and a man could know his boss. Now that concerns have grown so big a man hardly knows his foreman.

This reminds us of another department about to be started in the Ironbound Community Service. It is a foremen's organization of different factories and industries. Who would have thought of that twenty years ago? Through this we may learn of exceptional talent occasionally. And the long day's work may be made into a thing desired.

Good Americans There in the Making

The Ironbound District of Newark is not a fashionable quarter. But we believe there are Americans in the making there who may in time prove much more illumined leaders of us all than some of the most puffed up and vainglorious Senators in Washington today. The men are in earnest, the teachers are in earnest, the employers are in earnest, and social conditions have greatly improved since this movement has been under way. Maybe some day in addition to the reputation for high-class merchandise which the city of Newark enjoys there may be added the tradition that the men that came from Newark are upstanding and dependable; that they do not break faith; and that they bring with them ideals of fairness to all and of liberty through justice.

Commercial Testing of Metallurgical Electric Furnaces

A Comprehensive Outline of Methods to Be Used in Testing Metallurgical Electric Furnaces—Interpretation of the Collected Data, Summarizing the Results, Conclusions as to Suitability, Reliability, Production, Cost of Operation and Maintenance and Other Considerations

By H. M. ST. JOHN

DURING the past three years there has been a notable increase in the use of electric furnaces as applied to metallurgical processes, and the question of electric-furnace design and operation for various metallurgical purposes has become one of absorbing interest to many who previously had little knowledge of the subject. This development has not been without its publicity, but, among the valuable contributions which have filled so much space in the technical press, one searches in vain for a comprehensive discussion of suitable and adequate methods for use in testing furnaces of this type, for the purpose of determining their real economic value under any given set of conditions.

It is not the intention of the writer to attempt, in this article, the presentation of an authoritative and final exposition of testing methods, which might be accepted as a complete and trustworthy guide for use under any and all conditions. Desirable as such a conclusive statement of methods may be, it can result only from an open discussion, from different angles and by men of varied experiences, each of whom can contribute something not common to the experience of others. It is partly in the hope of arousing such a discussion that this article is written. If, at the same time, the results of the writer's experience prove to be of any value to others faced by similar problems, his purpose will have been completely served.

Three Factors to be Considered

The consideration of an electric-furnace installation for use in a metallurgical plant naturally resolves itself into three parts. First, it is necessary to select for trial some type of furnace likely to give the desired results in the work of that particular plant. Second, the furnace chosen must be subjected to an adequate test, to determine the quality of its performance as compared with other types of equipment, electric or otherwise, which are suitable for use on the same work. Finally, the furnace, once accepted as satisfactory, must be fitted into its place in the manufacturing scheme of the plant by the development and use of suitable operating methods, designed to secure a maximum of operating economy with a minimum of expensive supervision.

The question of initial selection of the furnace, and that of development of operating methods, are reserved for later discussion. Let us confine ourselves here to a consideration of electric-furnace testing and the interpretation of test results, principally for the reason that this phase of the matter has so often been neglected, sometimes with serious results.

In dealing with the commercial testing of electric furnaces, as differentiated from laboratory testing incidental to their experimental development, it is necessary to remember that, as a rule, at least three parties have a vital interest in the successful use of the furnace. These are the seller of the furnace, the prospective user, and the company which is to supply electric power for its use, or, if the manufacturing plant generates its own power, its power engineer may be considered as the third party. Each of these has important interests which must be satisfied, and no furnace test is complete which does not supply the necessary data to meet their varying requirements.

Failures Sometimes Due to Lack of Co-operation

The failure of certain furnace installations can be traced directly to a lack of co-operation among these three interested parties. In general, each has certain information and experience pertaining primarily to his own sphere of operations but having an important bearing, nevertheless, on the successful use of the furnace. The seller is familiar with the characteristics of his furnace, but is not likely to have complete knowledge of the requirements peculiar to the plant in which the furnace is to be installed, nor does he always realize the effect which these requirements will have upon the operation of the furnace. The manufacturer understands the necessities of his plant, but as a rule he is not familiar with electric-furnace operation and often does not understand that he can profitably modify the practice which he has previously adopted as suitable for use in connection with fuel-fired furnaces, in order that he may enjoy, to the fullest extent, the advantages of the electric furnace. Even if he is convinced that the methods in use in his plant should, so far as practicable, be made to conform with electric-furnace requirements, he himself, and his technical staff, are handicapped by lack of experience with electric-furnace operating methods. Neither the seller of the furnace nor the manufacturer who is to make use of it is likely to be aware of the special problems of electrical generation and distribution which must be solved in order that the power company may supply satisfactory service for the furnace at a reasonable cost, nor can they easily calculate what the cost of power will be under given conditions.

Central-Station Company of Assistance

With respect to these points, the central-station company occupies a unique position in that its true interests are identical with those of both the seller and the buyer, while at the same time it usually has at its disposal information dealing with the application of electric furnaces which is more general and comprehensive—if less detailed and specific—in its nature than is readily available to either of the other parties. As a result the power company is in a position to render a great deal of assistance in the development and proper application of electric furnaces in the territory which it serves, and is the natural arbiter in case of misunderstanding or dispute concerning the nature and conduct of acceptance tests. It has, of course, its own interests to guard, but these do not in any sense conflict with those of the

furnace manufacturer and the buyer, who may be termed the "mutual customer."

General Outline of the Test

The ultimate object of a commercial or acceptance test of an electric furnace is to determine the quality of its performance with respect to suitability, reliability and overall economy. With any furnace these factors vary widely, depending upon the conditions of its use, and it is accordingly necessary to consider them afresh in the case of each new installation.

In order to prove its suitability in any given field, the furnace must turn out a product of at least as high a quality as that ordinarily produced by the industry, using the raw materials and operating under the conditions which the general requirements of the industry impose. Its performance must be at least as good, in all essential respects, as that of equipment already in use in the same plant or in similar plants.

Having met the requirements of suitability by showing a high quality of performance when at its best, the furnace must further demonstrate its ability to maintain its favorable performance, day after day, under average working conditions. Sustained mediocrity is preferable to intermittent perfection. A furnace which requires delicate handling, frequent repairs and expensive supervision is not a satisfactory industrial tool.

Finally, the electric furnace, in order to make a place for itself, must show that it has, in addition to suitability and reliability, economic advantages which will make its use a money-saving, money-earning proposition. It must not merely be as good as other equipment used for the same purpose; it must be better. It must either turn out as good a product more cheaply, a better one at the same cost, use cheaper raw materials, require less labor, show a substantially greater production for the same capital investment, or in some equally important way prove its economic superiority.

Question to Be Answered

The electric-furnace test is expected to furnish the data by means of which these factors can be evaluated in dollars and cents, and an overall summation obtained for comparison with other furnaces. Other electric furnaces in other plants have proved that they possess some one or more of these advantages, and have consequently continued in successful operation; the question is: Can *this* furnace show that it has an economic right to exist in *this* plant?

The answer to this question lies in a thoroughgoing analysis of the furnace performance as related to plant operation, followed by correct interpretation of the results of analysis. It is the purpose here to discuss how this analysis can best be made and what form the interpretation should take, confining our attention to the various types of furnaces employed in the melting and refining of steel and non-ferrous alloys. These are the fields in which electric-furnace development is experiencing its most rapid growth and in which the practice of adequate methods of test is at present most needed.

In this class of work the data to be obtained from a comprehensive furnace test may be listed under the following heads:

1. Reliability and production.
2. Electrical characteristics.
3. Metallurgical characteristics.
4. Cost of operation.
5. Cost of maintenance.
6. Miscellaneous considerations.

The electric-furnace test proper naturally resolves itself itself into three parts: the preliminary test, the intensive test, and the operating test. These must sometimes be supplemented by various special tests to determine some one factor which cannot readily be studied under ordinary operating conditions. These three tests are of nearly equal importance, and no one of them can be omitted without seriously impairing the value of the test as a whole.

The Preliminary Test

Determining the Furnace's Suitability for the Work

The preliminary test covers the period from the time current is first turned on until the furnace is operating smoothly under regular plant conditions. This period will ordinarily include from one to two weeks, although it may be much more prolonged. During this time what has been termed the suitability of the furnace will be determined. If it is entirely unsuitable for the work, this fact will at once become apparent. If the lack of suitability is inherent and ineradicable, the furnace test is at an end and the furnace is rejected without further ado. If, on the other hand, it seems probable that the difficulty can be remedied by minor changes of design, the test may be continued, depending principally upon how far the furnace user is willing to co-operate with the seller in carrying on what must really be classed as additional development work of an experimental nature. In any event, the intensive portion of the test cannot be started until the furnace is operating smoothly under practical rather than experimental conditions.

If no serious defects develop in the furnace itself the period of the preliminary test is utilized in testing the auxiliary equipment and in co-ordinating the operation of the furnace with that of the plant as a whole. Defects in auxiliary equipment, such as motors, regulating devices, charging and conveying mechanisms, are frequently troublesome, but can usually be remedied without serious difficulty. These must all be in proper condition before the furnace can be given a fair trial. The facilities for bringing metal to the furnace and for removing molten metal after pouring must be at least as good as those in use with other furnaces in the same plant. In fact, it is often true that electric-furnace operation justifies more complete and efficient equipment of this nature than could profitably be used with other furnaces.

Co-ordination Important

Co-ordination of the furnace with other parts of the plant is no less important and often more difficult in a long-established plant than perfecting the operation of the furnace itself. Elimination of waste time, always of importance, is absolutely essential to the successful use of the electric furnace. Everything must be ready when it is needed, and every man, from the furnace operator to the laborer in the pouring gang, must know exactly what is required of him and be prepared to carry through his part immediately, whenever his services are needed. The electric furnace cannot be fairly tested until the operator, the weighmaster, the boss of the pouring gang and the foreman of the casting shop are thoroughly familiar with this requirement and ready to comply with it.

The time occupied by the preliminary test can also be utilized to good advantage by those who are to take

an active part in the test, in familiarizing themselves with the conditions which must be met. The operator may already be familiar with the characteristics of his furnace, but he must also learn the characteristics of the metal which the furnace is to melt, and the specific requirements as to pouring temperature, etc., which the furnace must satisfy. The man who is to supervise the test, and his assistants, must acquaint themselves with the nature of the furnace and other equipment and must obtain a good working knowledge of the manufacturing methods in use in the plant in so far as these have a bearing on the operation of the furnace. If these men are not members of the plant organization, they should become sufficiently familiar with it and its personnel to insure full and willing co-operation at times when such co-operation is of vital importance. Under such circumstances personal acquaintanceship and good feeling are essential to success.

The data taken during the preliminary test are of minor importance and should consist of an approximate determination of the electrical characteristics of the furnace and of such general observations as are required in order to co-ordinate the furnace with the rest of the plant. This includes a determination of the approximate time required for the melting operation, for the charging, pulling the slag, pouring, etc., the weight and mixture of charge which gives best results, and other factors upon which the operation of the furnace directly depends.

Intensive and Operating Tests

Determining Best Performance

The object of the intensive test is to determine the best possible performance of which the furnace is capable under the stipulated manufacturing conditions. A careful determination is made of all the factors which enter into the reliability and economy of furnace operation. This test normally requires from three days to a week, during which time skillful supervision and trained observation are necessary. It consists of a brief operating test, supplemented by such special tests as may be required, conducted in such a way as to establish standards of performance, with which the operation of the furnace later on, under more practical conditions, may be compared. The intensive test eliminates the personal equation of the human element so far as possible, and furnishes data which, if correctly interpreted, will demonstrate the virtues and defects of the furnace itself, as distinct from the men who are using it and the other foundry equipment with which it is used. Frequently these data will also point the way to improvement in design and modification of operating methods calculated to make of the furnace a more satisfactory foundry tool.

Operating Test Under Routine Conditions

When the intensive test has been completed, unless the furnace has already exhibited defects so serious as to make its further use undesirable, it should be put to work as a regular part of the plant equipment and operated steadily in a routine manner for at least a month. This constitutes the operating test, the final stage of the acceptance test. During this period the taking of data continues, but operating supervision should be limited to the degree which would ordinarily be employed if the furnace already occupied an accepted place in the foundry. The operating methods used should be based on the experience obtained during the preliminary and intensive tests.

The data taken during the operating test should include all points which have a direct bearing on the cost of production, but need not be so exact for each heat turned out as is desirable during the intensive test. The weight of metal melted and the kilowatt-hour consumption should be taken for each heat, as well as the time required for the melting operation; the metal lost in spillings and in the slag should be determined for the test as a whole, and, together with the weight of castings obtained, compared with the total weight of metal charged during the same period; the quality of metal and the percentage of defective castings, with the nature of the defects, should be carefully noted; irregularities in operation should be noted and traced to their sources; finally, the cost of maintenance should be determined as completely as is possible in such a comparatively short period of time.

Comparison of Figures

At the conclusion of the operating test the results obtained under regular manufacturing conditions should be compared with the more ideal figures taken during the intensive test, for the purpose of establishing what may be called the best practical performance of the furnace. This comparison is also useful in pointing out defects in furnace construction or operation which may perhaps be remedied. It is now possible to predict, with a fair degree of precision, what may be expected of the furnace as a tool, and to determine its status as compared with other types of melting equipment, for which accurate data may be at hand. On the basis of this prediction the furnace may be definitely accepted, tentatively accepted for further development and test—if circumstances seem to justify such a course—or definitely rejected.

The series of tests described may seem to some unnecessarily comprehensive and detailed, but in the procedure outlined it is merely proposed to carry out, carefully and according to a definite plan, work which is more often done aimlessly or without due consideration. It is only by careful and thorough test that one may learn in a relatively short time what the electric furnace will do in actual practice. It is far better to obtain reliable information on this point before one pays for the furnace than to learn later on, from a perusal of the yearly balance sheet, that the furnace has been unprofitable.

Testing Equipment

Selection of Measuring Devices Important

The selection and use of electric meters and other measuring devices is a matter of considerable importance in electric furnace testing. The permanent switchboard equipment of every electric furnace should include, at the very least, a watt-hour meter, to show the energy consumption of the furnace, and a voltmeter, to indicate the voltage across the furnace, if the latter is of either the arc or resistance type. In the case of the induction furnace the use of an ammeter, to show the current flowing in the primary circuit of the furnace, is perhaps of more importance. Ammeters are useful, in any case, especially with a 2-phase or 3-phase furnace, where it is desirable to detect any unbalancing of phases which may exist. An indicating wattmeter in the primary circuit enables the operator to tell at a

glance what his power input is, and is of distinct assistance to him. The use of a power-factor meter is advisable in the operation of any furnace which tends to have a low power factor, in order that the operator may be able at all times to keep the power factor at the highest practicable point.

Recording Instruments a Valuable Check

Recording instruments are valuable as a check on the operator, especially in case of 24-hr. operation, where the plant superintendent seldom sees the night operator. A glance at the instrument chart will show the time taken for each heat and the characteristics of the load, while comparison of the chart with the operator's report will indicate the cause of trouble, if trouble exists. Not more than one recording instrument need be used for this purpose, usually either a wattmeter or a voltmeter, or, in the case of the induction furnace, an ammeter rather than a voltmeter.

For purely test purposes a voltmeter should also be used on the primary side of the furnace transformer, since a comparison between supply voltage and furnace voltage is desirable, particularly with arc furnaces. If the permanent equipment of the furnace does not include a power-factor meter, it is necessary either to provide such a meter during the test or to add a wattmeter and ammeter to the voltmeter already specified for the primary circuit, in order that the power factor of that circuit may be calculated.

Current and Potential Transformers

These instruments must, of course, all be connected through suitable current and potential transformers. In the case of the watt-hour meter the ratios of these instrument transformers must be such that readings as small as one kilowatt-hour can be made with a fair degree of accuracy. It is only by a study of the energy consumption of the furnace during heats made at different times of day and under varying conditions that the highest economy of furnace operation can be attained. The watt-hour meter used by the power-supply company—upon the monthly readings of which the power bills are based—cannot ordinarily be read with sufficient exactness to be suitable for test purposes.

The temperature of the molten metal delivered by the furnace is of great importance, and, during the test period at least, should be known as exactly as possible. The metal should, of course, always be heated to the temperature required by the casting shop, but additional superheat is expensive and should be avoided, because the added energy required to produce even a few degrees of unnecessary superheat is relatively large. In melting brass or other alloys which contain a volatile constituent, unnecessary superheat also means unnecessary loss of metal and added expense on that score. Energy consumption and metal loss figures cannot be properly interpreted unless one knows the temperature at which each heat is poured.

The temperature of molten alloys up to 1250 or 1300 deg. C. (2280 to 2370 deg. F.) can be measured by means of a base-metal thermocouple, and such an instrument should be provided for this work. In the present state of the art the constant use of a thermocouple for registering molten metal temperatures in regular practice is often too expensive and inconvenient, but for test purposes the trouble and expense involved are well justified. Under these conditions the ordinary steel protecting tube cannot well be used, since it is rapidly attacked by the molten alloy, and also because its thermal lag results in a slow reading. A bare couple gives rapid results which are fairly accurate if the determination is made with care. The couple is consumed rather rapidly by the action of the molten metal and its use is, therefore, somewhat expensive. It is not necessary to maintain the weld at the tip of the couple, since, if the elements are not allowed to separate widely, sufficiently good contact is made through the molten metal. Special protecting tubes may also be used, which, while rather expensive and having a tendency to retard the reading, are suitable for test purposes. It is usually more convenient to measure the temperature of the metal after it has been poured into the ladle rather than to attempt measurements of metal still in the furnace.

In the case of steel or other metals which are poured above 1300 deg. C. (2372 deg. F.) the problem of temperature measurement is an extremely difficult one, since the use of a thermocouple immersed in the metal is no longer practical. The use of an optical pyrometer, provided with a special temperature scale calibrated for the light emissivity of molten iron and steel, has been proposed, but such a pyrometer is very expensive and its value for this purpose limited. By installing a thermocouple permanently in some part of the wall or roof of the furnace it is possible to get relative temperatures which may be found useful. This practice is also advisable in the case of certain resistance furnaces which have a high capacity for absorbed heat, not so much for the purpose of estimating metal temperatures, but in order to limit the rate of heat input to a safe value.

The whole question of temperature measurement and methods is one which merits a much more detailed discussion than can be given it here. Its importance in metallurgical tests of all kinds can hardly be overestimated and it should be given careful study by the engineer who conducts such work.

Other Instruments Needed

Other instruments needed for the electric furnace test are thermometers, stopwatches and a water meter, although the last named, while useful for determining the amount of water used for cooling purposes and for regulating the rate of water flow, can be dispensed with. Unless it is used, however, the amount of heat dissipated in the cooling water can be found only by weighing the quantity of water which passes through the cooling system in a specified time. A thermometer should be used to measure the temperature of the water supply, another to measure the temperature of the water as it leaves the furnace. The furnace transformer should be equipped with a thermometer to measure the temperature of its oil, and the room temperature in the immediate neighborhood of the transformer should also be taken. Stopwatches can be used to advantage in measuring various time intervals during furnace operation.

All instruments to be used during the test should be calibrated and tested very thoroughly, as inaccurate meters betray the confidence of the user and sometimes lead to serious errors.

Reliability and Production

Reliability and rate of production are closely linked, although the latter also depends, in marked degree, on the power input and thermal efficiency of the furnace. In judging reliability it is very important to make a distinction between delays in operation due to failure of

the furnace and delays due to lack of co-ordination between the furnace and other parts of the foundry. Interruptions in the continuity of furnace operation resulting from a failure of the weighmaster's department, or the casting shop, to meet the furnace requirements on schedule time are largely avoidable and should not be charged against the furnace. A distinction should also be made between unavoidable delays, resulting from defects inherent in the design of the furnace itself, and interruptions due to defective operation of auxiliary apparatus, such as tilting mechanism, electrode-operating devices, etc. These, together with such loss of time as may be due to lack of skill on the part of the operator, are also, for the most part, avoidable.

The Furnace Log

Most of the information upon which conclusions with respect to reliability and production are to be based is contained in the furnace log. This log should be kept carefully throughout, from the time power is first turned on until the end of the operating test. In it should be noted the time interval required for each principal phase of the furnace operation, together with all irregularities and their cause, and such other happenings as may seem to have a bearing upon the performance of the furnace. In tabulating and interpreting the mass of data which must be digested, after the final test has been completed, it is often possible to explain puzzling and seemingly contradictory results by a glance at the log for the particular heat in question. The principal data for each heat should be kept in an orderly manner on a separate sheet, and, for the sake of convenience, should be unaccompanied by remarks or other extraneous matter.

Sample of a Log

Following is given, as an example, a log for two consecutive heats of an arc furnace melting a copper alloy:

HEAT NO. 10

Time A.M.	Remarks
3:25	Started charging
3:30	Power on
3:41	Power off to add new electrode
4:15	Power on
4:45	Power off to remove slag, metal ready
4:55	Started pouring
5:00	Finished pouring

HEAT NO. 11

Time A.M.	Remarks
5:00	Started charging
5:10	Power on
5:20	Power off to adjust electrode
5:23	Power on and off immediately, broken electrode, new one added
5:28	Power on
5:32	Power off to adjust electrode
5:34	Power on
6:05	Power off because of changing shifts
6:12	Power on
6:14	Power off to remove slag
6:19	Power on
6:25	Power off, started pouring; spilled quite a bit in pouring
6:30	Finished pouring

The conduct of both of these heats is open to criticism, which, however, should not be directed toward the furnace. In the first heat 34 minutes was required to add a new electrode section, although the normal time for this operation was not more than 5 minutes, as was the case during the second heat. The man keeping the log neglected to note down the reason for the abnormal delay in the first case, a regrettable omission, as such delays are serious and should always be traced to their source. The loss of 7 minutes because of changing shifts was inexcusable. Such losses of time look small, when considered separately, but loom large when taken in the aggregate. On the day when these two heats were made, the total of lost time, not in any way attributable to the furnace or its auxiliary equipment, amounted to 1 hour and 20 minutes, ample time for another heat to have been made. Examination of the data sheet for these heats showed that in each case the energy consumption was abnormally high, which was readily explained by the fact that the time consumed was at least 50 per cent more than necessary. The gross metal loss in Heat No. 11 was excessive, and a glance at the log gave the answer as "spilled metal."

Log Useful in Many Ways

The log, then, is useful in answering riddles propounded by eccentric data, but it serves an even more useful purpose in a way which has a direct bearing on the study of reliability and production. Its record should be analyzed and tabulated to show the manner in which time has been spent, usefully or otherwise. Time lost due to failure of the furnace, failure of the auxiliary equipment, lack of skill of the operator and dilatoriness on the part of other foundry employees can each be summed up and given its proper label as avoidable or unavoidable. It is then possible to judge the reliability performance of the furnace fairly and to estimate what production it is capable of giving if the avoidable delays are eliminated, or at least reduced to the point where added supervision brings diminishing returns.

Such a time analysis, made on the operation of an arc furnace in another plant, and covering a period of several days, showed the following conditions:

	Per Cent of Total Time	
Time power on		57.1
Time power off		
Charging, pouring and pulling slag	20.2	
Electrode adjustment and trouble	5.7	
Motor trouble	3.1	
Lunch period	2.2	
Balance of time (wasted)	11.7	
		42.9

By eliminating unnecessary superheating of the metal, arranging the operating schedule so that the furnace was not interrupted during lunch periods, utilizing time which had formerly been altogether wasted and reducing the time spent in electrode adjustment and for remedying troubles of various kinds from 8.8 per cent of the total time to 3.3 per cent, greatly improved results were obtained from this furnace. An average production of 19 to 20 heats per 24 hr. was raised to 24 heats, without changing the furnace in any way, and at the same time the operating cost per ton of metal was greatly reduced. This will illustrate the importance of analyzing the test results in order to credit the furnace with the performance of which it is really capable.

The nature of metal charged, especially its cleanness and state of physical division, must also be considered in determining production. Ingots, chips and borings, thin scrap, heavy scrap, foundry gates and sprues, punchings, concentrate from the recovery plant, etc., will, as a rule, melt down much more rapidly if they are mixed with one another than if an attempt is made to melt any one class by itself. Borings or chips which are oily or wet are particularly troublesome if they are not mixed with cleaner metal in larger pieces. The production of the furnace must be estimated on a basis of the quality of charge which it will actually be called upon to handle. If test results are obtained under conditions which are either uncommonly favorable or peculiarly unfavorable, due allowance must be made for that fact.

Electrical Characteristics

The electrical characteristics, including power input, power factor and steadiness of load, play an important part in determining the output of the furnace, the rate which must be paid for electric energy and the desirability of the load from a central-station viewpoint. If the electrical characteristics of the furnace load are manifestly undesirable in any important respect, the central station may require the furnace user to install auxiliary equipment in order to modify and compensate for the objectionable features. Such equipment is likely to be expensive and must be taken into consideration in determining the installation cost and the investment charges. This applies particularly to large single-phase furnaces in a district supplied by 3-phase power, to furnaces which tend to have a low power factor and to furnaces which are subject to violent fluctuations of power. It is necessary to determine how these factors will influence the cost of power and of the initial installation in the district where the furnace is situated. It may, for example, be necessary to install a motor-generator set, or a phase converter, in order to improve the characteristics of the load; otherwise the power company may be compelled to isolate the furnace load by building a special line to the plant, in which case the manufacturer is likely to be called upon to deposit for a term of years part of the first cost of the new line. On the other hand, if a high-voltage power line, of large capacity and devoted exclusively to power business, happens to be conveniently located, even a single-phase, low power-factor load can be handled by the power company without serious inconvenience.

Power Input

The average power input is measured by taking frequent readings on the wattmeter, or, if a recording wattmeter is used, may be integrated directly from its charts. This result should be checked against the energy input shown by the watt-hour meter. The variations in power input are also of importance; its maximum points and their duration should be noted.

The rate of power input has a direct effect on speed of production, and from that standpoint should be raised to the highest possible point. It is limited, however, by other considerations. For example, in the case of copper alloys, most of the constituents of which are somewhat volatile, too high a power input results in local overheating and excessive metal losses. Steel is not so sensitive, but the best furnace refractories available will not stand up against too rapid generation of heat, at the high temperatures of the steel furnace. In the induction furnace the power input, for a furnace of given size, is limited by still other considerations which need not be discussed here.

Rate of Power Input Important

The rate of power input also has a direct influence in determining the rate paid for electric power. Power, in quantity, is almost universally sold on a schedule which bases the rate on two factors, the maximum demand, and the quantity of energy used. The demand charge consists of a fixed monthly rate per killowatt of demand, and is in addition to the energy charge of a certain sum per kw-hr. used during the month. By maximum demand, in the case of an electric furnace, is meant the highest average power input, during a specified period of time, which has been recorded for the furnace. The period of time taken as a unit of measurement is specified in the rate schedule of the power company, and varies, with different companies, all the way from 5 min. to 3 hr. The methods employed in measuring maximum demand also differ greatly. For example, in one city the maximum demand is taken as the highest average input during any 5-min. period which happens to be selected, and the determination is made with a watt-hour meter and a stopwatch. In another city the maximum demand is taken as the average input during any three individual hours which show the three highest averages, and the determination is made by means of a permanently installed instrument which records the input every 15 minutes.

The maximum demand so determined usually holds good for a considerable period of time (often 12 months) unless it is superseded during that time by a still higher demand, which, in its turn, becomes effective for a similar period. In determining the cost of energy to be used by the furnace it is evidently important to be in a position to predict what maximum demand the furnace will show under the particular rules and regulations which govern the sale of power in the locality where the furnace is to be used. The ideal power curve, from this standpoint, is a straight line, with a maximum average and minimum which are identical, an ideal which, of course, is not satisfied by any electric furnace.

The most desirable power input, under the given conditions, should be approximately determined during the preliminary test, and this value should continue to be used until a more suitable one is established by the intensive and operating tests.

Power Factor

The power factor of resistance or induction furnaces may be measured by means of a power-factor indicator, or may be calculated from the readings of an ammeter, voltmeter and wattmeter. The power factor of an arc furnace may be roughly determined in the same manner, but frequent and violent fluctuations of the power input render it impossible to obtain a very accurate result, unless an average is taken from a large number of readings spread over a considerable period of time. These methods, imperfect as they are in the case of the arc furnace, are, nevertheless, the best means available for learning the variation in power factor during the changing conditions of a single heat, or for comparing separate heats.

When it is desired to determine the average power factor of the furnace during a period of a week or more, the sine-meter method is much to be preferred, and serves equally well with arc, resistance or induction furnaces. In this method two watt-hour meters, differently connected, are used, and, by the use of suitably plotted curves, power factor is calculated from the ratio of the reading of one instrument to that of the other. The method cannot be explained in detail here, but can be found, fully discussed, in standard works on electrical measurements.

In any case, power-factor measurements should be taken in the supply circuit—on the high side of the furnace transformer. The power factor in the furnace circuit is often much higher than that of the supply circuit, and the latter is the significant value.

Since a low power-factor load results in as great a demand on the current-carrying capacity of the power line as does a heavier load at a correspondingly higher power factor, the load with unsatisfactory power factor

is sometimes penalized by means of a higher demand charge. This penalty is applied in the case of all power factors below a certain specified minimum, usually in the neighborhood of 60 or 70 per cent.

Determining Power Factor Under Differing Operating Conditions

It is often desirable to learn what the power factor will be under differing operating conditions. This can best be done during the preliminary test, since, during later tests, uniform operating conditions are to be preferred. The curve in Fig. 1 shows the relationship between arc voltage and power factor in a high-voltage single-phase arc furnace. The power factor of this furnace was low and was subject to a penalty for all values below 70 per cent. It was, therefore, important to maintain the power factor at a point as close as possible to 70 per cent, if higher values proved unattainable. This test, and the curve showing its results, indicated the advantage of operating the furnace at an arc voltage as high as possible with relation to the supply voltage. At higher arc voltages the arc became unstable and could not be held.

The nature of the charge, under the conditions just mentioned, also has an appreciable influence on the stability of the arc, and hence on the power factor. This applies somewhat to the physical nature of the charge, but more particularly to its composition. The presence of any constituent which tends to stabilize the arc makes possible a higher arc voltage and more favorable power factor; the reverse is equally true. Some metals—zinc, for example—have a depressing effect on the arc

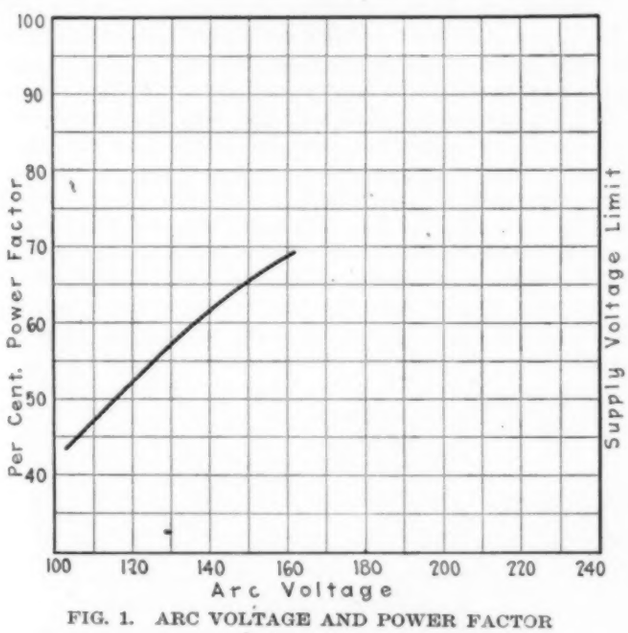


FIG. 1. ARC VOLTAGE AND POWER FACTOR

and, if present in considerable quantity, prevent the maintenance of a high-voltage arc. Certain slagging materials, on the other hand, have a stabilizing influence and improve the power factor. In one case it was found that the concentrates from the foundry recovery plant had a very marked and favorable influence when they formed a considerable percentage of the charge. The various kinds of materials normally making up the furnace charge in the plant, and their effects on the arc, will govern the practice to be followed.

The relative steadiness of load can be determined, imperfectly by observation, more satisfactorily by the use of a recording wattmeter in the supply circuit. This point is of no great importance to the furnace user, except in its effect upon the attitude of the power supply company. The latter will usually be able to learn from charts taken in its station or substation whether the furnace load is exercising a seriously detrimental influence on its power line. If the power fluctuations are so violent, relative to the capacity of the line, that other customers of the company who take power from the same line are inconvenienced, it is necessary either to transfer the furnace load to a line of higher capacity or to isolate it entirely by building a separate line for its exclusive use. In the case of 2-phase or 3-phase furnaces, unbalancing of the phases may be a serious factor, which, unless it can be overcome by the furnace user, must be remedied by isolation or by the use of compensating equipment.

Resistance and induction furnaces are, as a rule, fairly free from violent fluctuations, and do not tend to unbalance the phases unless they are single-phase furnaces, in which case the unbalancing effect can be definitely predicted.

Adequacy of Electrical Equipment

The adequacy of the electrical equipment which supplies the furnace must be learned by observation throughout the series of tests. The furnace transformer and the leads connecting it with the furnace have undoubtedly been chosen to take care of the expected power input at the expected power factor, with an ample margin of safety. If, however, the power input is unexpectedly high, or the power factor not so favorable as had been supposed, the transformer may be dangerously overloaded. The difference in temperature between the transformer oil and the surrounding air, taken when the furnace has been drawing its maximum load for some time, will indicate whether the transformer is likely to overheat seriously at any time, during a hot summer day, for example.

Low power factor may, in some cases, be caused by improperly designed or poorly placed leads, a condition which can be promptly detected and rectified. This subject has been thoroughly discussed by Lindstrom[1] and by Meyer.[2]

Metallurgical Characteristics

The metallurgical characteristics include the loss of metal during the melting operation, the quality of the metal with respect to the uniformity of its composition and the absence of undesirable impurities, the ease with which a specified composition can be produced, and the uniformity of temperature at which the metal is delivered from the furnace. It is upon these features of its performance that the superiority of the electric furnace commonly depends, and they must be determined with great care. With respect to all of these points it is desirable to get an exact comparison between the electric furnace under test and other furnaces operating on the same kind of work under similar conditions.

Metal Loss

The weight of metal lost during the melting process has a direct bearing upon the cost of operation, whether the metal is irrevocably lost or can be partially recovered from slags, ashes, sweepings, etc. The object

[1] A. Lindstrom: "Leads for Electric Furnaces," Met & Chem. Eng., vol. 16, p. 683 (1917).

[2] A. A. Meyer: "Electrical Characteristics of Electric Furnaces," *Trans.*, Am. Electrochem. Soc., vol. 31, p. 269 (1917).

of the melting process is to supply useful metal in the ladle or crucible, ready for pouring into castings or ingot. Metal not delivered to the ladle, but which can, nevertheless, be recovered, must obviously be remelted before it becomes useful, and such recovered metal can be credited to the furnace only at its premelted value, after due allowance has been made for the cost of recovery. The gross loss, by which is meant the difference in weight between metal charged and useful metal in the ladle, may sometimes be a more important factor than the net loss, or the discrepancy between metal charged and total metal delivered useful plus recoverable. A furnace showing a gross loss of 3 per cent, with a net loss of 2 per cent, is likely to be more economical than another which operates at a gross loss of 10 per cent and a net loss of only 1 per cent. On the other hand, if the net loss is low, a high gross loss is commonly due to carelessness, and this possibility must be considered in judging the furnace.

Two general methods are in use for determining metal loss, the choice of which depends upon the nature of metal melted, and also upon the object to be attained. The method of direct weighings must be used when handling a single metal, and is commonly to be preferred in the case of an alloy which contains a considerable percentage of a volatile metal. This includes copper and all of its alloys. Determination of metal loss by chemical analysis applies more particularly to the case of an alloy whose predominant constituent is non-volatile, and which contains small quantities of volatile metals. Many alloy steels fall in this class. The method may also be applied to certain ferro-alloys.

Loss by Direct Weighing

The method of direct weighings may be applied in either of two ways. The most accurate determination of net loss, in the case of copper and its alloys, can be made by pouring the molten metal into ingot molds at the furnace, taking great care to avoid spilling. The furnace is then scraped as clean as possible and these scrapings, together with the slag and spillings, are put through a hand recovery process. The difference between weight of metal charged and weight of ingots is the gross loss for that individual heat. The weight of metal recovered, added to the weight of ingots, is then subtracted from the weight charged, to determine the net loss. Instead of pouring the metal into ingots, the molten metal may be weighed in the ladle. This, however, involves some sacrifice of accuracy and is not to be recommended. Whenever it is worth while to learn the metal loss for individual heats, scrupulous care is justified in making the determination. The metal loss for individual heats becomes of importance when it is desired to learn, within the limits of a short test, the effect of different rates of power input, different pouring temperatures and other variations in operating conditions upon metal loss.

If uniform operating conditions are to be maintained, and it is desired to learn what the average melting loss will be under these conditions, separate determinations for individual heats are not necessary. Under these circumstances it is permissible to weigh the molten metal in ladles, and it is not necessary to scrape the furnace clean or even to pour out the entire melt. The slag and spillings from individual heats need not be kept separate, but should be stored apart from similar accumulations of other furnaces. At the end of a series of heats—preferably ten or more—the furnace should be entirely emptied and cleaned. The accumulated slag and spillings are then weighed and the recoverable metallic content determined. This may be done by hand recovery of a carefully selected sample, or by putting the whole lot through a recovery plant, if such is available. By this method good average results can be obtained, sufficiently accurate to indicate the performance of the furnace in this particular.

In determining metal loss by direct weighings three precautions must be observed. In the first place, the metal charged is often far from clean and, in the case of oily or wet borings, may not be more than 95 per cent metallic. Scrap castings, sprues and gates sometimes introduce a considerable quantity of sand. These nonmetallic constituents of the charge may be responsible for a considerable error unless proper allowance is made for them. In case an appreciable weight of metal is added to the melt in the ladle, the addition should be credited as metal melted by the furnace. This correction will reduce the calculated loss somewhat, and plays an even more important part when the consumption of electric energy per ton of metal melted is considered. Metal loss determinations must never be made with a newly lined furnace, since, during the first two or three heats in a fresh lining, metal will seep into the cracks and pores of the refractory; as a result the net metal loss will appear to be about double the normal value.

Loss by Chemical Analysis

The chemical analysis method for determining metal loss is based on the assumption that at least one constituent, which must form a considerable percentage of the charge, is not subject to selective loss; that is, it neither vaporizes nor oxidizes during the melting operation. Any loss of this constituent which may occur is supposed to be due to spilling or spattering, in which case all constituents of the belt are lost in the same relative proportion, and the analysis of the alloy is unchanged. The composition of the charge is known or determined by analysis, and a sample of the metal poured is analyzed. The difference between these analyses is assumed to be due to volatilization or oxidation of constituents other than the one considered stable.

Suppose that we have an alloy which consists of two metals, A and B, and that the analyses, before and after melting, are as follows:

Metal	Before Melting, per Cent.	After Melting, per Cent
A	75.0	76.5
B	25.0	23.5
	100.0	100.0

If we consider that A has suffered no loss—except, possibly, by spilling—we can calculate as follows:

Let relative weight of A before melting	= 100.0
Then relative weight of B before melting	= 33.3
And relative weight of alloy before melting	= 133.3
According to assumption:	
Relative weight of A after melting	= 100.0
According to analysis:	
Relative weight of B after melting	= 30.7
Then relative weight of alloy after melting	= 130.7

Relative loss of alloy = 133.3 — 130.7 = 2.6
Percentage loss of alloy = 2.6 ÷ 133.3 = 1.95

We conclude, then, that for every 100 lb. of alloy melted we are losing 1.95 lb. of metal, which we assume consists wholly of B, and evaluate our loss accordingly. This, of course, is a net loss, since we cannot very well determine the weight of our spillings by chemical analysis. In respect to determining the gross loss, this method, even at its best, is deficient.

But suppose that there is, after all, a slight loss of metal A, by volatilization or oxidation, much smaller

than the loss suffered by B, but still appreciable. Let us say that this loss of A amounts to 0.25 per cent of its original weight. By recalculation we find that, on this basis, our net loss is 2.20 per cent, of which 0.19 per cent is A and 2.01 per cent is B. On a large tonnage basis, this difference between 1.95 per cent and 2.20 per cent would be an important item.

The method of chemical analysis has often been used to calculate zinc losses in the melting of brass and, in doing so, it is always assumed that the relative amount of copper in the alloy remains constant. This is not a correct assumption. There is almost invariably some oxidation of copper, and, in some cases, volatilization as well, with the result that losses calculated in this way are always too low. When we consider the added fact that a slight error in chemical analysis, or a slight lack of uniformity in the alloy as sampled, results in a disproportionately large inaccuracy in the result, it will be seen that this method, by itself, is not suitable for use with copper alloys. It is often valuable, however, if used in conjunction with the method of direct weighings. After the net loss of the alloy as a whole has been learned from the weights taken, the proportionate loss of the constituent metals can be determined by chemical analysis. This is of especial value in case the alloy contains three constituents, two of which are subject to considerable loss. If the three metals differ widely in market value, it is important to learn the proportionate loss of each, in order that the total loss may be correctly evaluated.

In the case of alloy steels, where the alloying constituent is exceedingly valuable, usually added in small quantities, and often subject in marked degree to volatilization and oxidation, determination of loss by direct weighings is of little value. Relatively speaking it is safe to assume that the proportion of iron is stable, and the chemical analysis method can most advantageously be used.

Temperature of Metal Important

Whatever method is used in determining metal loss, it is of great importance to know the temperature at which metal is delivered from the furnace during the test, particularly in the case of copper alloys. According to Gillett[3], yellow brass (67 per cent copper, 33 per cent zinc) boils at approximately 1120 deg. C. (2048 deg. F.), while the correct pouring temperature for this alloy, if it is to be used in thin castings, is about 1075 deg. C. (1967 deg. F.). This leaves a margin of only 45 deg. C. between the desired pouring temperature and the boiling point of the alloy, at which latter point zinc will be volatilized at a high rate. It is obvious that no reliable comparison can be made between two heats, one of which is poured at, say, 1120 deg. C. (2048 deg. F.) and the other at 1050 deg. C. (1922 deg. F.), unless the difference in temperature is known and its effect discounted. In fact, metal loss figures, not accompanied by a statement of the temperature at which they are taken, lose much of their value and may become a source of serious misunderstanding. Determination of molten metal temperatures, by the best available means, is of the greatest importance, especially during a short test which is expected to furnish data from which estimates of economy can be made.

The quality of metal from the electric furnace should be carefully compared with that obtained from other sources, since superiority in this respect is often the determining factor in the success of electric furnace operation. The basic qualities to be considered are homogeneity of composition and structure, and the absence of undesirable impurities. Upon these depend strength, the percentage of satisfactory castings, and other mechanical and physical properties which have a direct bearing upon the value of the product.

The structure of the metal may be superficially determined by examination of fractures. In some cases this point may be of sufficient importance to warrant a thorough metallographical examination. The presence of impurities and their percentages may be determined by the usual methods of chemical analysis and microscopic examination.

If the strength of the finished casting is of any importance under the conditions to which it is to be subjected in use, suitable tests should be made to determine its strength properties, as compared with castings from metal melted in other furnaces. These tests should, of course, take the form necessary to show what the performance of the casting will be under service conditions, depending upon whether it is to withstand hydraulic pressure, air pressure, steam pressure, tensile or compressive stresses, etc. It is sometimes found that the casting made from electrically melted metal is of appreciably greater strength than castings otherwise produced. This may justify a higher sale price for the casting, or it may make possible the use of a lightweight casting with strength equal to that of heavier castings previously used. In either case the additional profit, or the saving, should be properly accredited to the electric furnace.

Defective Castings

Defective castings are a constant source of loss which the foundryman struggles in vain to eliminate, and finally compromises by achieving what he concludes to be an irreducible minimum. This trouble is commonly due to a variety of causes, some of which are not in any way related to the condition of the molten metal as it leaves the furnace. Others, however, can be ascribed to the quality and physical state of the metal, and these can sometimes be almost eliminated by electric melting. So far as practicable, castings from the electric furnace should be separately inspected during the progress of the acceptance test, in order that the percentage of acceptable castings may be compared with similar figures from other furnaces.

In some cases the electrical conductivity of the product is of importance. Tests should be made to determine whether or not the metal from the electric furnace is inherently superior in this respect, and whether the methods commonly used to produce high electrical conductivity can be more easily applied and exactly controlled in the electric than in other furnaces.

In certain instances it has been found that electric steel castings lend themselves unusually well to heat treatment, with the result that the treated castings are of more uniformly high quality than castings from metal melted in other furnaces and subjected to the same heat treatment. Tests should be made to determine the presence of this quality, since it may be a source of saving or of additional profit.

The attainment of a specified metallic composition, within narrow limits, is sometimes an essential in the production of ingot metal or of castings for special purposes. The degree of ease and exactness with which

[3] H. W. Gillett: "Brass-Furnace Practice in the United States," U. S. Bureau of Mines Bull. No. 73, page 129 (1914).

this can be done in the electric furnace, as compared with other furnaces, should be determined in such cases.

The uniformity of temperature at which metal is delivered from the furnace is important in many ways. When once the correct pouring temperature for an alloy to be used on certain work has been learned, the strictest possible adherence to that temperature will prevent lost heats, save time, result in economy of heat units, minimize metal losses, and make for uniformity in the metal itself. The ease with which the electric furnace under test lends itself to temperature control is a factor to be considered.

In the refining of steel it is sometimes worth while to give separate consideration to the performance of the electric furnace as a melting furnace and as a refining furnace. It may function admirably for one purpose and be almost worthless for the other. Again, its reliability may be high when merely dead melting in an acid lining, while an attempt to carry out a refining process, in a basic lining, may result in a prompt destruction of the refractories. It is unsafe to conclude from a satisfactory performance under one set of conditions that the furnace will be equally successful under a quite different set of conditions. Each point must be considered with reference to the work which the furnace is expected to do, and the cost of removing phosphorus and sulphur, as well as that of carburization, may well be treated as distinct from the cost of melting.

Cost of Operation

The cost of operation is made up of the cost of electric energy used per ton of metal produced, the cost of slagging materials, etc., the cost of labor, the cost of operating auxiliary equipment, such as tilting, electrode-adjusting and water cooling devices, and the expense for carbon, graphite and similar parts which are regularly consumed as a part of the furnace operation.

The cost of electric energy depends upon the thermal efficiency of the furnace and upon those of its electrical characteristics which tend to govern the rate at which electric power is sold. The influence of the power input, the power factor and the steadiness of load have already been discussed. The exact estimation of these factors must be based on local conditions and on the stipulations imposed by the company which is to supply power for the furnace.

Energy Consumption

The quantity of electric energy required by the furnace per ton of metal melted can be stated in various ways, and the published statements concerning this requirement are sometimes very misleading. In one sense the significant value is the number of kilowatt-hours consumed per ton of molten metal delivered in the ladle. This is the economic figure upon which estimates of production cost must be based, but it is contingent, not merely upon the efficiency of the furnace, but also upon the weight of non-metallic material in the charge—which must be evaporated, melted or at least heated to incandescence—and upon the weight of metal volatilized, oxidized, absorbed by the furnace lining, skimmed off with the slag or spilled before it reaches the ladle. From the standpoint of determining the furnace efficiency it is better to base the kilowatt-hour consumption upon the weight of metal charged, thus eliminating the other factors mentioned which have nothing to do with this quality of the furnace. Any statement of energy consumption should be accompanied by information as to the sort of metal charged, whether it is in the form of borings, recovery plant concentrates, light scrap, heavy scrap, ingot or a mixture of these, and whether it carries with it an appreciable quantity of non-metallic material. The state of the metal in these respects plays an important part in determining energy consumption. The approximate temperature at which the metal is poured should also be stated.

In the case of steel any figure given for kilowatt-hour consumption is practically worthless unless all metallurgical conditions are known, whether the process consists of dead melting cold scrap, melting and refining cold scrap or refining a molten charge. In the process of dead melting the energy consumption will be largely influenced by the percentage of iron oxide, or rust, included in the charge. In refining, the percentage of phosphorus and sulphur in the charge, as compared with their percentage in the finished product, plays an important part. The percentage of carbon in the finished steel must also be considered.

During the acceptance test this question of energy consumption must be dealt with from two standpoints. First, what is the inherent thermal efficiency of the furnace, at the required temperature, independent of metallurgical considerations? The final decision as to the heat economy of the furnace, and modifications of design or of operating methods calculated to improve such economy, depend upon an accurate determination of this point. Second, how many kilowatt-hours, per ton of metal produced, will be used by the furnace, in its present form and under the conditions imposed upon it by plant requirements? An adequate answer to this question is required in order that a correct estimate of production cost may be made.

Heat Balance

The inherent thermal efficiency of the furnace is found by making a heat-balance determination. The heat generated in an electric furnace is disposed of in four ways: (1) A portion of the heat is dissipated from the walls and other parts of the furnace by radiation and by convection, (2) another portion is carried away in the water used to cool electrode holders, roof rings, etc., (3) a third portion is lost in the hot gases which escape through the electrode openings, open doors and crevices in the furnace structure, (4) the final and useful portion is absorbed by the metal in raising its temperature to the melting point, melting it and superheating it to the required pouring temperature. If a water-cooling system is not used this source of loss is, of course, eliminated. In determining the heat balance it is usual to make an estimate, based on theoretical considerations, of the heat absorbed by the metal—the pouring temperature of which must be known—measure the heat lost in the cooling water, approximately measure the radiation losses and evaluate other losses by difference. The ratio of heat absorbed by the metal to total heat input is the thermal efficiency of the furnace under the particular conditions existing when measurements are made.

When an electric furnace is started from the cold its walls absorb heat rapidly and radiate it very slowly. As time goes on this heat absorption decreases, radiation losses increase, and the furnace finally reaches an equilibrium at a temperature which depends upon the rate of power input and upon the nature of the metal being melted. Up to this point, the thermal efficiency, starting at a low value, has been increasing, and it reaches its maximum at the equilibrium temperature. The furnace

walls may now be said to be saturated, i.e., they contain all of the heat they are capable of holding at the equilibrium temperature. So long as the equilibrium is maintained, the quality of heat held by the walls remains constant, and the rate of radiation loss from the outer walls exactly equals the rate of heat absorption by the inner walls. If the power input is sensibly decreased, the inner walls feed heat back to the metal in the furnace, the equilibrium temperature drops and the radiation losses decrease. During this time the thermal efficiency will apparently be abnormally high, perhaps even higher than 100 per cent, but this apparent value s a false one, since the metal is really receiving part of its heat from heat energy previously stored in the furnace walls. This heat energy must be restored to the walls before the former equilibrium temperature can be regained and a normal rate of melting at a normal efficiency once more attained. If the furnace is allowed to stand inactive the stored heat is lost by radiation from the walls, at a rate which decreases more and more gradually. If the furnace is restarted before the stored heat is altogether gone the remaining portion serves a useful purpose as a foundation upon which to build in restoring the temperature of the furnace to its normal operating value.

Determining Loss of Heat During Night

When an electric furnace is operated during the day only, the loss, during the night, of heat energy which has been stored in the furnace walls during the day may become a very serious matter, especially in the case of a heavily-lagged resistance furnace. In testing such a furnace it is worth while to determine, as accurately as possible, what is the absorption capacity of the walls and how much residual heat is still left after the furnace has stood idle for several hours. An exact determination of these values is laborious and inconvenient; an approximate determination, which is at the same time sufficiently accurate, can be made more easily.

For this purpose, a test should be made, starting from the cold, with the furnace empty. The power input should be high enough to heat the furnace about as rapidly as would be the case in actual practice, and the temperature of the furnace chamber should be meas ured at frequent intervals, by means of a pyrometer. A base metal couple may be used for the lower ranges, but above 1300 deg. C. it is necessary to employ a radiation or optical pyrometer, or some other form of instrument more suited to the higher range. When the furnace has reached its maximum operating temperature the power input should be reduced until it is just sufficient to maintain the temperature at the desired point. This power input—the exact value of which should be determined as closely as possible—is, then, equivalent to the rate of heat loss, expressed in kilowatts, by wall radiation, cooling water, and other sources, at that particular temperature. The power should now be turned off and the furnace allowed to cool, with temperature readings taken at frequent intervals as before.

A cooling curve, drawn from these data, showing furnace temperature plotted against time, may be used to determine rate of heat loss at any given temperature during cooling, and also the quantity of heat still stored in the walls. Such a curve is shown in Fig. 2, illustrating a temperature drop from 1500 deg. C. to 450 deg. C. in 14 hours. In this case the power input required to maintain a temperature of 1500 deg. C. after the furnace had reached an equilibrium at that temperature was 40 kw. At any given moment the rate at which heat is being lost is proportional to the slope of the cooling curve at that point. Knowing this loss to be 40 kw. at the instant power was shut off, the rate of loss at any other point may be determined graphically by the use of the triangles shown, each having a base which represents one hour's cooling, and an altitude which is proportional to the instantaneous rate of cooling at the beginning of the hour.

For example, the rate of cooling at the beginning of the second hour is to the rate of cooling at the beginning of the first hour as b is to a. We already know

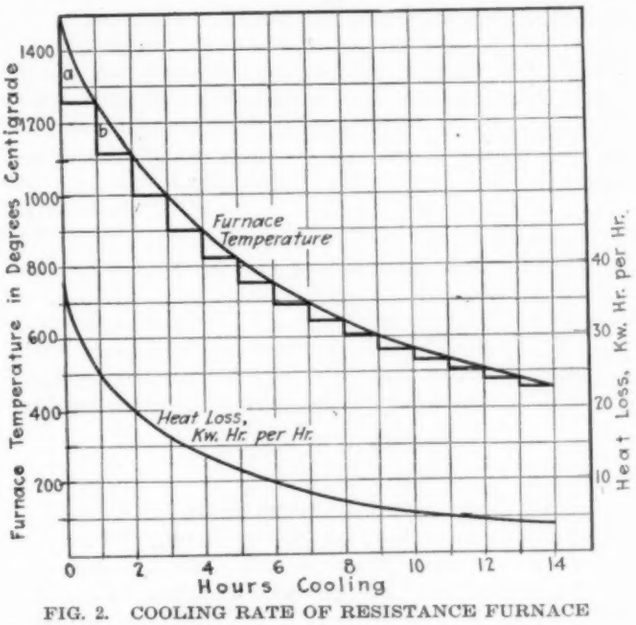


FIG. 2. COOLING RATE OF RESISTANCE FURNACE

that a corresponds to 40 kw., and we find by measurement that $b:a::15:24$. Thus we have $b:40::15:24$; $b = 25$ kw., the instantaneous cooling rate at the beginning of the second hour. The lower curve in Fig. 2 shows the rate of cooling throughout the 14-hr. period, determined in this manner for each hour.

It cannot be claimed, of course, that this method gives absolute accuracy, but it does give approximate accuracy in a manner which is at once simple and useful. The cooling curve is exponential and has an equation which is complicated and does not lend itself to rapid calculation. As given, it includes not only the radiation losses, but also the losses by convection of heated air currents, losses in the cooling water—if this is used and continues to flow afer the power has been shut off—and losses by direct conduction where the furnace comes in contact with its supports. In determining the thermal characteristics of a furnace it is of great advantage to group these losses under a single head and thus be able to calculate their net effect. To be strictly correct, one must use as ordinates in such a diagram as shown in Fig. 2, not the actual furnace temperature as measured, but the difference between this temperature and the temperature of the air surrounding the furnace. If cooling water is used, the fact that its temperature is probably lower than room temperature introduces an additional complication, for which correction can be made if desired. In practice these refinements are troublesome and by no means essential, so long as one is dealing with temperatures not lower than 400 or 500 deg. C.

In a furnace which is cooling from a temperature at

which it was in a state of equilibrium—that is, saturated with as much heat energy as it would hold at that temperature—it is approximately correct to say that the heat content of the furnace, at any time, expressed in killowatt-hours, is directly proportional to the temperature of the furnace chamber. This is not strictly correct, because the specific heats of the various materials of which the furnace is built are not constant at all temperatures, but experience has shown that the assumption is sufficiently exact for the purpose we have in mind. We can now determine the heat content of the furnace by assuming, first, that the average rate of loss during any hour is the mean of the rates of loss at the beginning and at the end of the hour, and, second, that the total heat loss between any two furnace temperatures is proportional to the difference between those temperatures. On this basis we find that our furnace has lost 32.5 kw.-hr. of stored heat during the first hour, 22.5 kw.-hr. during the second hour, and so on to a total of approximately 158 kw.-hr. during the whole 14-hr. period. During this time the furnace temperature has dropped from 1500 deg. C. to 450 deg. C., or 70 per

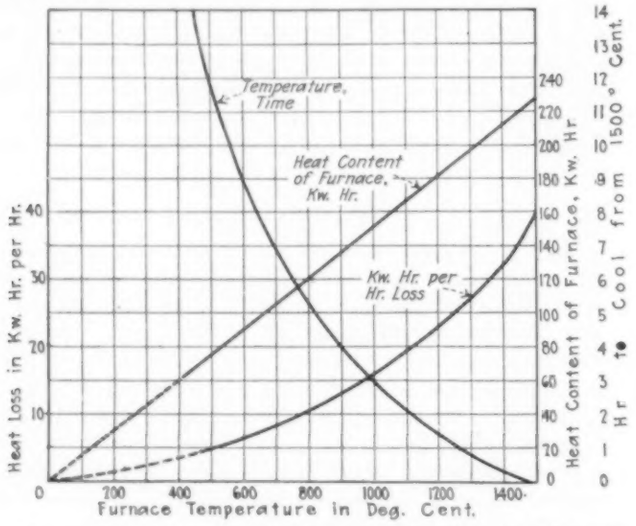

Temperature, Time
Heat Content of Furnace, Kw. Hr.
Kw. Hr. per Hr. Loss
Heat Loss in Kw. Hr. per Hr.
Heat Content of Furnace, Kw. Hr
Furnace Temperature in Deg. Cent.
Cool from 1500° Cent. to Hr

FIG. 3. THERMAL CHARACTERISTICS OF RESISTANCE FURNACE

cent, and therefore, according to our assumption, has lost 70 per cent of its stored heat. The total heat storage at 1500 deg. C was, then, 100 ÷ 70 × 159, or 226 kw.-hr., of which 68 kw.-hr. remained in the furnace at the end of 14 hours.

In Fig. 3 curves are given, based on these data, which show killowatt-hours per hour loss, killowatt-hours heat content of furnace, and hours required to cool to a given temperature, all plotted against furnace temperatures. These curves form a complete diagram of the net thermal characteristics of the furnace, upon which operating schedules may be based, and the correctness of furnace design for the particular work in question may be judged.

Fig. 4 shows an application of this method, in which, under conditions of 10-hr. operation, a test was made to determine the effect of residual heat energy at the beginning of the day, on the time required to complete the first heat, and on the thermal efficiency of the first heat. The higher values of residual energy were obtained by the application of a small power input during the night, the economic value of which in terms of production and operating efficiency could thus be determined without prolonged test.

Fig. 5 shows a diagram of one day's operation, in which the percentage of total energy input, as utilized and dissipated in various ways, is plotted against the total input expressed in killowatt-hours. *A* represents the heat absorbed by the metal, calculated as 160 kw.-hr. per ton of brass at 1090 deg. C. (1994 deg. F.), *B* the various heat losses from the furnace during operation, and *C* the heat absorbed by the furnace structure as its temperature rises. In each of the rectangles shown in the diagram, the altitude indicates the percentage of

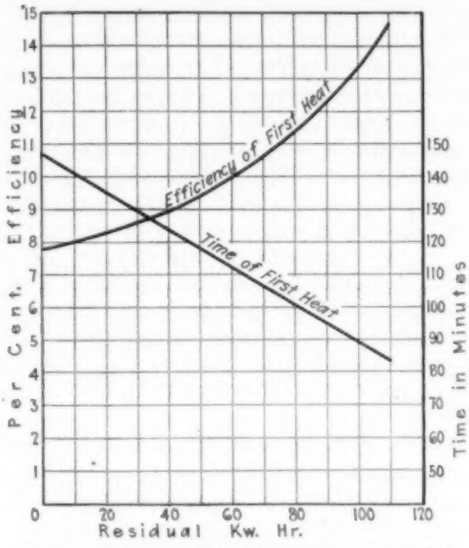


FIG. 4. RESIDUAL ENERGY-EFFICIENCY AND TIME, FIRST HEAT OF DAY

heat input disposed of in the manner indicated, while its area is proportional to the heat input in kilowatt-hours. In rectangles marked *A* the altitude represents also the thermal efficiency of the furnace during each heat. The shaded areas indicate the heat energy stored

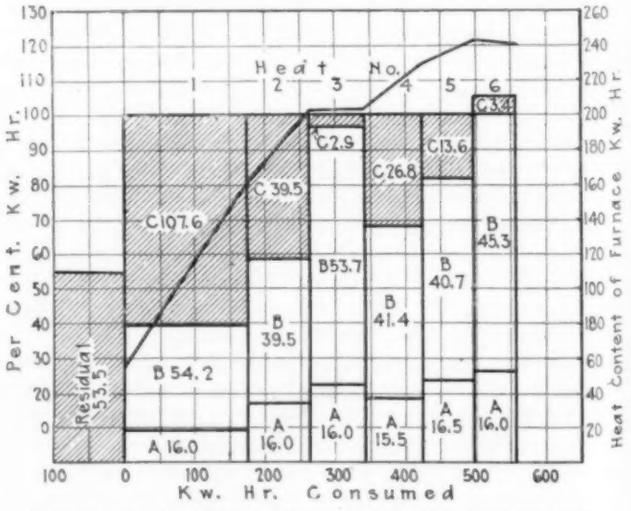


FIG. 5. HEAT BALANCE OF RESISTANCE FURNACE

in the walls of the furnace, that marked "Residual" being the initial stored heat with which the furnace started the day. The figures show the numerical values of each area in kilowatt-hours. The broken-line curve indicates the rate at which heat is being stored by the furnace, or —what is virtually the same thing—the rate of temperature rise.

It will be noted, in this diagram, that during the first two heats a relatively enormous amount of energy was

being stored by the furnace and its temperature increased rapidly. The third heat covered part of the lunch period, during which power was turned off. As a result the furnace temperature increased very little and the apparent efficiency was comparatively high. The efficiency dropped during the fourth heat as the rate of heat absorption by the furnace again increased. The maximum operating temperature of the furnace was not reached until the end of the fifth heat. During the sixth heat the furnace "coasted," that is, the power input was reduced to such an extent that the furnace temperature began to decline slowly, and the furnace walls gave up part of their stored energy to heat the metal and supply radiation losses, which is shown graphically by the fact that the rectangle *C* is above the 100 per cent line and really has a negative value. At the same time this coasting caused the apparent thermal efficiency to rise to a value somewhat higher than the true efficiency.

In the study of heavily lagged resistance furnaces, such curves and diagrams as these, based on data covering only a few days' operation, are of more value than weeks of operation unsupplemented by graphical interpretation. By the use of these methods the performance of the furnace under different conditions, as well as its merits and defects of design, can be evaluated with surprising accuracy, and desirable changes in design and operating methods can be made with a considerable degree of precision.

Cooling-Water Loss

In making a heat balance it is sometimes desirable to know what portion of the energy input is being carried away in the cooling water. This is determined by measuring the temperature of the incoming and of the outgoing water, and weighing the water used during a certain time period, or measuring the water by means of a water meter. Multiplying the weight of the water in pounds by its temperature rise in degrees F. gives its acquired heat content in B.t.u., and this may be converted into killowatt-hours by dividing by 3416. The rate of heat loss in killowatts may then be determined by dividing the heat gain in kilowatt-hours by the fraction of an hour during which the observed weight of water was used.

Several such determinations are necessary in order to get a good average value, and it is sometimes advisable to determine the rate of loss at different speeds of cooling-water flow, and to observe the general effect of this variation on furnace operation, in order that the use of cooling water may be so adjusted as to obtain the highest overall economy. The magnitude of this loss is frequently in the neighborhood of 10 per cent of the total power input, and, under favorable conditions, may be much higher.

While the heat-balance determination indicates the fundamental thermal characteristics of the furnace *per se*, the only way to learn what the energy consumption will be under practical conditions in any specified plant is by careful observation of the kilowatt-hours used from heat to heat. Since different heats are often subject to different conditions, it is important to note the energy consumption on each heat and to accompany these data with an adequate description of the conditions—such a description as given by the furnace log—in order that the effect of varying conditions may be learned. For this purpose, as already stated, it is necessary to use a watt-hour meter, the readings of which may be estimated with fair accuracy to 1 kw.-hr. as a unit, unless the furnace is large, using, say, as much as 1000 kw.-hr. per heat—in which case readings taken in tens of kilowatt-hours are close enough.

During the preliminary test one should learn approximately what energy consumption is to be expected. The brief intensive test should furnish data to show the best results of which the furnace is capable, when operating under regular plant conditions but subject to very careful supervision. These figures may be used as a basic value with which to compare results obtained during the more extensive operating test, with supervision reduced to a practical minimum. The information thus obtained, together with the heat balance, is sufficiently comprehensive to justify complete estimates covering the effect of all conditions likely to be encountered, the relative economy of various operating schedules which may be proposed, the advisability of changes in design, and the influence of human factors such as skill of the operator, attitude of foremen and laborers in the plant, etc.

The energy consumption per ton of metal depends in marked degree upon the temperature to which the metal is heated by the furnace. Useful comparisons are impossible unless the approximate temperature of the metal is known. The importance of the pyrometer in electric-furnace testing has already been emphasized, and, in connection with determinations of energy consumption, can hardly be overemphasized.

Materials and Labor

The cost of raw materials includes fluxes and slagging materials, and the cost of the metal charged. Fluxes, etc., constitute a relatively small item, but one which, nevertheless, should be recognized and included in the balance sheet. The cost of metal charged is a production rather than an operating cost, but, under certain conditions, should be included under operating costs as a differential when comparisons are to be made with other types of furnaces. For example, if it is found that the electric furnace requires a less expensive grade of metal than is used by some other furnace, in order to turn out the same quality of product, the difference in cost should be credited to electric-furnace operation. Or if, as sometimes happens, the electric furnace can utilize as part of its charge badly oxidized or otherwise impure material which would otherwise have to be sold at a loss, this saving should be credited in a similar manner. Of course, if the reverse is true, the differential consists of a charge against the electric furnace instead of a credit.

Throughout the acceptance test the labor required to operate the electric furnace should be carefully observed, in order that the labor necessary, not merely as to quantity but also with respect to quality, may be accurately estimated when the test has been completed. The comparison between the intensive test and the operating test, the latter with reduced supervision, will indicate how expensive a grade of labor is justified on economic grounds.

Auxiliary equipment, such as tilting motors and electrode-regulating apparatus, must ordinarily receive their power supply from a separate circuit, since the characteristics of the furnace circuit are usually unfavorable to their operation. Their use of electric energy may be estimated, if desired, but is so small as compared with that used by the furnace that the cost of energy consumed in this way is not an important factor. The cost

of water used in cooling electrode holders or other parts of the furnace equipment may under some conditions deserve a place in the table of costs, although it is, of course, small.

The cost of carbon, graphite or other materials of a similar nature, which are employed in electrodes or resistor parts, is an operating cost, provided these materials are regularly consumed during operation. Such materials as are relatively long-lived, and replaced at irregular intervals, are more properly considered under the head of maintenance cost.

Carbon and graphite parts are usually purchased by the pound, and the weight consumed per ton of metal produced should be determined. In the case of electrodes for arc furnaces, where breakage is an important factor, it is worth while to differentiate between electrode consumption and electrode breakage. This can be done by weighing the broken pieces of electrode, from time to time, as they accumulate, and comparing this weight with the total weight of electrodes used during the same period. Electrode breakage is, theoretically, an avoidable waste and a good deal of time and effort can profitably be spent in reducing it to a minimum. Any pronounced discrepancy between electrode consumption, as determined during the intensive test, and that found in practice during the operating test should be thoroughly investigated.

Maintenance Cost

The cost of maintenance includes the expense involved in renewing the refractory parts of the furnace from time to time, and in making such repairs as may be necessary on the furnace and its auxiliary equipment. The necessary observations include the nature and weight of materials used and the quantity and quality of labor required, all to be reduced to a basis of cost per ton of metal output. If the renewals and repairs involve serious interruptions of operation, special consideration must be given them under the head of reliability and production.

The cost of refractories is difficult to determine in a test of short duration. If the furnace is well designed, and well suited to its purpose, its refractory parts will not need very many or very extensive renewals during the course of a two-months test, and it is not easy to estimate from the results of such a test what the cost of refractories will be over a period of, say, one year. The best estimate which can be made must be based on close observation of the condition of the roof and lining at frequent intervals. In the case of an arc furnace the roof may have to be replaced one or more times, particularly if the furnace is operated continuously, and the cost of renewal should be carefully noted. In an induction furnace the lining will be subject to much more rapid wear than the roof, and the effect of alternate heating and cooling, if the furnace is not run continuously, should be carefully noted.

Consideration for Saving in Materials

In making cost estimates with respect to refractories, due consideration should be given to the possibility of using less expensive or more durable materials, which may happen to be well suited to the work in question. For example, it has been found that in melting certain classes of copper alloys in an arc furnace, roofs constructed of ordinary firebrick are not only cheaper in first cost than those of silica brick, but are also more durable.

Miscellaneous Considerations

There are a variety of miscellaneous factors, not so far considered, which play either a direct or an indirect part in determining the cost of production or the overhead expense of the plant. Taxes and interest charges on the investment, the loss involved in disposing of equipment already in use, depreciation and obsolescence charges against the electric furnace equipment, make up one group which affects production cost directly. If the electric furnace makes possible a saving in floor space which is really needed for other purposes, or if it reduces the insurance rate for the plant, these are also items which can be evaluated with a fair degree of exactness.

Depreciation and obsolescence charges lend themselves excellently well to what may be termed scientific juggling resulting in almost any conclusion which the juggler may wish to reach. A few general principles should be observed in making such estimates. In the first place, the transformers, foundations, furnace leads, instruments, etc., should always be included with the furnace. As a rule these items are specially designed for use with the particular furnace in question, and are of much less value for any other purpose. Their depreciation should be calculated at the same rate as that of the furnace.

No well established rule will be found for calculating electric-furnace depreciation. The proper rate to use will vary with circumstances. The writer has in mind one installation, just going in, where a depreciation rate of not more than 5 per cent per annum might well be used. In applications where a well standardized furnace has long been used in other plants for the same purpose, 10 per cent is a conservative value. This applies particularly to certain well known furnaces widely used for melting and refining steel. In other cases, where the application is a relatively new one and the electric furnaces now in use are pioneers, obsolescence becomes the governing factor and 20 per cent is a safer value. There are some installations, established solely as a result of the abnormal conditions existing during the war, which lost about 90 per cent of their value on the day the armistice was signed.

The advantages of greater cleanliness and less noise, which often favor the electric furnace, as well as that of greatly reduced radiation of heat, which always accompanies electric-furnace operation, are of such a nature that they cannot be exactly evaluated. The net effect of such indirect advantages is very different in different locations, depends largely upon the type of fuel-fired furnace with which the electric furnace is being compared, and, in its influence on working conditions and other considerations, both economic and æsthetic, its importance will depend upon the climate, the class of labor employed, the location of the plant with respect to residence sections and other buildings, public or private, and finally, on the attitude of the plant management in dealing with considerations which have to do principally with the welfare of employees and questions of public interest. The question of poisonous and unpleasant fumes and gases given off during the melting operation has a similar bearing on the subject. In this connection the degree of ventilation which already exists in the plant, or may easily be attained, must also be considered.

Up to this point we have considered separately the individual features of electric-furnace performance, the

bearing which each has upon the performance as a whole, and methods for obtaining adequate and reliable data with respect to these factors during the progress of an acceptance test, made in an industrial plant under commercial conditions. When the test has been completed and the desired information is all in hand, there still remains the task of summarizing the results, scrutinizing each detail in the light of its influence on the final result and giving to each its proper weight, totaling the costs and estimating what these will be under such variety of conditions as are likely to be met with in the plant concerned, comparing these costs with corresponding figures obtained from other sources, and, finally, giving judgment as to the overall value of the furnace for use in the plant in which it has been tested. The correctness of the conclusions reached will depend no less on the use of good sense and engineering judgment in interpreting results than on the skill and care with which the test has been made.

Questions to Be Answered

The engineer charged with the task of judging the quality of performance which the furnace has shown must, after a careful study of the data, arrive at the correct answers for the questions given below, preferably to be considered in the order given. Not all of these questions need be considered in every case. Which of them are pertinent depends upon the nature of the furnace tested and upon the requirements of the plant in which its use is proposed.

A. Suitability

Is the furnace suitable, in a general way, for the work which it is expected to do? Will it produce a marketable product from suitable raw materials without any gross failure to meet the requirements of the industry in other respects? If it is lacking in this regard, is its failure due to some fault inherent in its design, or can its performance be rectified by minor changes in construction or operating methods?

B. Reliability

Is the furnace sufficiently reliable in its operation to be classed as an industrial tool? If its apparent reliability leaves something to be desired, what part of the trouble should be ascribed to the furnace itself and what to imperfections in its auxiliary equipment or other contributing causes? Can the difficulty be overcome in any practical way?

C. Production

What rate of production can the furnace be expected to show under the conditions normally existing in the plant? Can this rate be increased, under existing conditions, by changes in furnace design or operating methods? What rate of production is the furnace capable of, if conditions are modified to meet its requirements? Does the increased production thus made possible seem to justify the necessary modifications?

D. Nature of Metal Handled

Is the furnace capable of handling in a satisfactory manner all of the various forms of metal which it is desired to use in this plant? Is it more or less satisfactory than other furnaces in this respect?

E. Electrical Characteristics

1. *Power Input.* What is the average power input of the furnace under the various conditions of its use? Is it, for any reason, desirable to raise or lower this input, and, if so, how readily can this be done?

2. *Power Factor.* What is the average power factor of the furnace? Is it so low as to subject the furnace load to a penalty which will affect the rate paid for electric energy? If there is danger of this, how can the power factor be maintained at the highest practicable value?

3. *Steadiness of Load.* Is the power input subject to violent fluctuations which may be dangerous to the transformers or objectionable to the power company? If so, how can this condition best be remedied?

4. *Adequacy of Electrical Equipment.* Are the transformers, leads and other electrical equipment suitably designed and connected for use with the furnace? If not, what changes should be made?

5. *Rates for Electric Power.* With the electrical characteristics of the furnace as they are, and at the estimated use of power, what will be the average cost per unit of electric energy used? Can this cost be reduced?

Are the electrical characteristics of the furnace such that it constitutes an undesirable load for the local power company or for the power system of the plant? How readily, if at all, can undesirable characteristics be improved? Are conditions such that it will be necessary to install additional equipment in order to compensate for undesirable characteristics? If so, how can this best be done and what will it cost to install and operate such equipment?

F. Metallurgical Characteristics

1. *Metal Loss.* What gross and net metal losses are experienced with the furnace under the conditions of its use? How does it compare with other furnaces in this respect? Can the results obtained during the test be improved upon? What is the value of the loss expressed in cost per ton of metal produced?

2. *Quality of Metal.* How does the quality of metal produced by the furnace compare with that from other furnaces, judging it according to the purposes for which the finished product is to be used? Is it likely that better results can be obtained? Does the furnace make possible a product which can be sold at a price above the average? Does it make direct savings in production as compared with other furnaces?

How do the metallurgical characteristics of the furnace compare with those of other furnaces used on similar work? Can the furnace be improved in this respect?

G. Cost of Operation and Maintenance

1. *Energy Consumption.* What energy consumption does the furnace show, per ton of metal produced, under the conditions of its use? In this respect, how does the furnace compare with other electric furnaces doing similar work? Is the furnace capable of giving better results?

2. *Thermal Efficiency.* What is the inherent thermal efficiency of the furnace? How well do its thermal characteristics conform to requirements imposed by the operating schedule of the plant? Can these characteristics be changed for the better? Would it be advantageous to modify the operating schedule?

3. *Cost of Carbon and Graphite Parts.* What is the cost, per ton of metal produced, for electrodes or other carbon and graphite parts? How much of this cost is necessary and how much due to avoidable waste? What seems to be the minimum practicable cost of this item? How does the furnace compare with other electric furnaces in this respect?

4. *Labor.* What is the labor cost per ton of metal produced? Can this item be reduced? Would it decrease if the installation were to be enlarged by the addition of more furnaces? How does this cost compare with that for other furnaces, electric or fuel-fired? What grade of labor should be employed to produce most economical results?

5. *Metal Charged.* Does the furnace show greater or less economy than other furnaces with respect to the grade of raw materials which it utilizes?

6. *Miscellaneous Materials.* What is the total cost, per ton of metal produced, for incidentals such as fluxes, slagging materials, water, etc.?

7. *Refractories.* What is the cost, per ton of metal produced, for renewing furnace refractories? How does the furnace compare in this respect with other electric furnaces? Can the overall economy be improved by substituting cheaper or more durable refractories for some of those now in use?

How does the overall cost of operation compare with that of other furnaces under similar conditions? Is it probable that this cost can be reduced?

H. Other Considerations

1. *Depreciation.* What rate should be charged for depreciation or obsolescence of the electric furnace installation? What does this amount to in cost per ton of metal produced, on a basis of the estimated production?

2. *Interest and Taxes.* What is the estimated cost, per ton of metal produced, for interest and taxes on the electric furnace investment?

3. *Miscellaneous Economic Considerations* Does the furnace make possible a saving in plant insurance rates

as compared with other furnaces in use or under consideration? Does the furnace make possible a saving in floor space which is really needed for other purposes?

4. *Working Conditions.* Does the furnace possess advantages over other types of furnaces with respect to cleanliness, silence of operation, absence of excessive radiated heat, freedom from noxious gases and fumes, and the like, which have a bearing on the health and efficiency of the workmen, and, in general, on the hygienic condition of the plant and its surroundings? Of what importance are these advantages under the conditions which exist in and around the particular plant in question?

Summarizing these factors, does the furnace possess peculiar advantages, as compared with other furnaces, by virtue of its ability to utilize cheaper raw materials, or its ability to save materials otherwise unavoidably lost, or its ability to turn out a product of higher grade?

Exclusive of such of these advantages as it may possess, does the furnace show a higher or a lower operating cost than other furnaces?

Considering both special savings and operating costs, how does the overall economy of the furnace compare with that of other furnaces under consideration?

Does the furnace possess incidental qualities, not easily evaluated in dollars and cents, which have any bearing for or against its use?

Considering the overall economy of the furnace, together with such special and incidental advantages as it may possess or lack, does it seem advisable to choose this particular furnace as new equipment in preferance to other furnaces which might be used?

What loss would be involved in selling, or consigning to the scrap pile, other furnaces already in use in the plant, and replacing them with additional electric furnaces of the type under test? Is this action advisable?

If the present superiority of the electric furnace for use in this plant is based on abnormal conditions, what will be its status when these conditions no longer exist?

If the adoption of the electric furnace is not now advisable, is it likely to become so under changed circumstances which may be expected to arise in the future?

In answering these questions the engineer who is reporting the test will have covered very thoroughly all of the technical and economic factors which play a part in the success or failure of electric furnace installations in the field under discussion. The matter of general supervision and plant overhead is not included, as this question depends upon many factors which have little or nothing to do with the electric furnace, factors concerning which the engineer who is testing the furnace can hardly be expected to have complete information. In any case this item will be much the same for one furnace installation as for another, provided the rate of plant production is identical. The plant manager, if he has before him such a report as that indicated above, can reach a final decision concerning the furnace, which will be based on all the facts, accurately determined and adequately presented.

Detroit Electric Furnace Co.,
Detroit, Mich.

Industrial Analysis of Gas Mixtures by the Refractometric Method

THE June, 1919, issue of *Chimie et Industrie* contains a comprehensive description of the application of interference phenomena to the industrial analysis of gas mixtures, by Prof. Marcel Pouchon.[1] The following is an abstract of this interesting study.

The volumetric and gravimetric methods of gas analysis present disadvantages which are not encountered when using the method based on the variation of the index of refraction of gases. To obtain the index of refraction of a gas mixture it is necessary to know the index of each of the components. The refractometric method is applied easily when analyzing a binary mixture. For more complex mixtures this method does not offer any appreciable advantage over the standard volumetric and gravimetric methods.

The main difficulty encountered in the application of this method is the smallness of the value to be measured. Thus, the difference of the index of refraction between pure air and a mixture air-carbon dioxide (say 95 per cent air, 5 per cent carbon dioxide) is about 10^{-5}. To obtain results accurate to within $\pm$ 1 per cent, the readings have to be taken with an exactitude of 10^{-7}. This extreme sensibility is secured by the application of the phenomena of interference as obtained when using Lord Rayleigh's gas interferometer.[2]

Lord Rayleigh's Portable Interferometer

There are two types of gas interferometers, the laboratory type and the portable type. The portable type (Fig. 1), which is used industrially, is represented schematically in plan and elevation in Figs. 2 and 3[3]. It consists of (1) a vertical slit F_1F_2, source of light s, lens l, mirror m and prism p; (2) a lens L the focal plane of which contains the slit F_1F_2; (3) two glass plates C,C' of which the plate C' is movable around the horizontal axis aa; (4) a glass parallelopiped P; (5) a plane mirror M; (6) two gas chambers G,G' closed at their parallel extremities with glass plates.

Principle of the Apparatus

At F_1, the upper part of the slit, there are formed two pencils P_1 and P_1' which pass through the plates C,C', the gas chambers G,G', then are reflected by M back through the gas chambers G,G', and plates C,C', and form after passing through the lens L interference bands in F_1'.

At F_2, the lower part of the slit, there are formed two pencils P_2 and P_2' which pass through the lens L

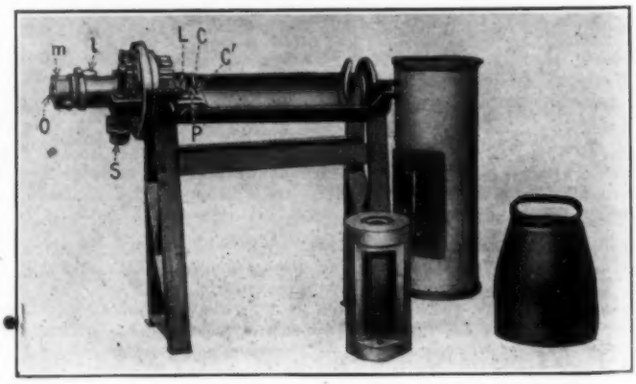


FIG. 1.

and are then deflected by P so as to sidestep the gas chambers G,G' and reflected by the mirror M back through P and L, when the pencils form bands in F_2'.

These two systems of bands are spaced one over the other and separated by a horizontal black band. The observations are made through a cylindical lens O. The

[1] Prof. Marcel Pouchon, "Analyse industrielle des Mélanges Gazeux par la Méthode Réfractometrique." *Chimie et Industrie*, June, 1919, pp. 647-655.

[2] Lord Rayleigh, *Proc. Roy. Soc.* (A), vol. 59, 1896, and vol. 64, 1898. F. Lowe, *Physik. Z.*, vol. 11, 1910.

[3] The laboratory type of Lord Rayleigh's gas interferometer is described by Frank M. Seibert and Walter C. Harpster in the U. S. Bureau of Mines Technical Paper No. 185, 1918.

central band only is achromatic, the others are colored and can be easily distinguished.

By turning the plate C' around the axis aa the path of the pencils P' and P_1' can be varied and by this means displace laterally the upper system of bands. The two central bands can thus be aligned. Under these conditions the optical paths followed by the pencils P_1 and P_1' are the same. The displacement given to C' is measured by the micrometer screw S (see Fig. 1).

Method of Operation

To measure the difference of the index of refraction of two gases it is first necessary to start with filling the two gas chambers G and G' with a standard gas, and by manipulating the micrometer screw S, C' is brought to the position where the two central bands are in alignment, and the position of the micrometer is noted. This is the zero point. Now one of the gas chambers, say G', is filled with the gas to be studied and the central bands are again aligned by means of S. The new position of C' is noted, and the displacement of the micrometer screw S measures the variation of the optical path of P' when the standard gas is replaced by the

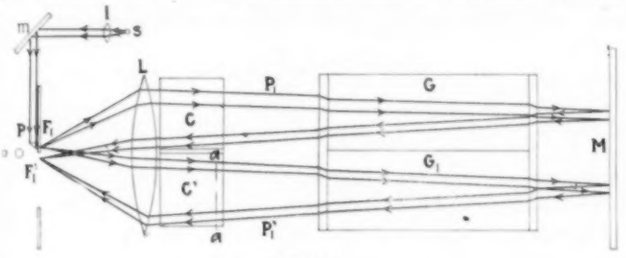


FIG. 2

gas to be studied. This displacement is a function of the difference of the index of refraction of the two gases.

Every apparatus has to be standardized, by using as standard gas and as a gas to be studied gases whose indices of refraction are well known, such as carbon dioxide, ammonia, etc.

The displacements of the micrometric screws are proportional to the variation of the index, i.e., the readings plotted with the micrometer displacements as abscissæ and the difference of indices of refraction as ordinates give a straight line (see Fig. 4). This is the standardizing curve. The sensitiveness of the apparatus depends on the length of the gas chambers G, G': The longer the chambers, the more sensitive the apparatus.

Although the apparatus once standardized can be considered as such indefinitely, it is better to restandardize it from time to time and check the standardizing curve.

Analysis of a Gas Mixture

A gas mixture is analyzed by comparing it to one of its constituents taken as standard gas, and the results are calculated by the application of the following laws:

(*a*) *The refractivity of a gas is proportional to its absolute density.*

$$\frac{N-1}{D} = \text{constant} \qquad (1)$$

in which N is the absolute index of refraction of the gas and D the absolute density or mass per unit volume of the gas under given conditions of temperature and pressure.

(*b*) *The refractivity of a gas mixture is equal to the sum of the refractivities of each of the gases at the pressure they would have if they were to occupy individually the total volume.*

$$N - 1 = (N_1 - 1) + (N_2 - 1) + \ldots . \qquad (2)$$

in which N is the absolute index of the mixture and N_1, N_2, ... the indices of the components at the pressure they would have if they were to occupy individually the total volume.

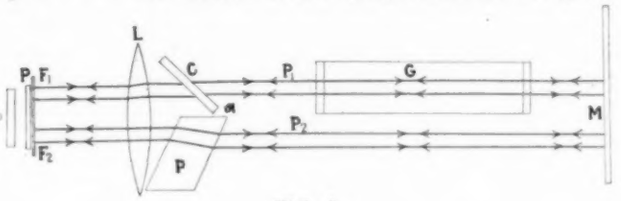


FIG. 3

From these two formulæ it is found that for a binary mixture if N_1' is the index of refraction of a pure compound initially filling the gas chamber G', N'' the index of the mixture to be analyzed, p_2 the mass of one of the components contained in a unit volume of the gaseous mixture and d_2 its relative density (the other component being taken as the standard)

$$p_2 = d_2 a \frac{N'' - N_1'}{N_2 - N_1} \qquad (3)$$

when the gases filling the gas chambers G and G' are at the same temperature and pressure.

The weight of the constituent not taken as standard, contained in the unit volume of the mixture at the experimental temperature and pressure, is proportional to the difference between the index of refraction of the

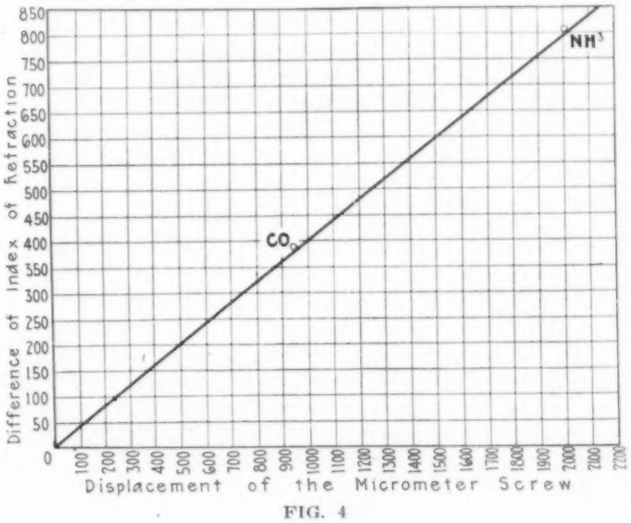


FIG. 4

TABLE I—VERIFICATION OF THE PROPORTIONALITY OF THE DISPLACEMENT OF THE MICROMETER SCREW TO THE WEIGHTS OF ONE OF THE CONSTITUENTS IN THE UNIT VOLUME OF THE MIXTURE

Gas Mixed with Air (1)	Composition of the Mixture to Be Studied (2)	Displacement of the Micrometer Screw (3)	Value (2) / Value (3) (4)
	Grams per cu.m.	Divisions	
Carbon dioxide	49.0	96	0.510
	313.0	613	0.510
	585.0	1140	0.513
	1230.0	2410	0.510
Ethyl alcohol	67.5	436	0.154
	87.0	565	0.154
	100.0	635	0.157
	114.0	734	0.155

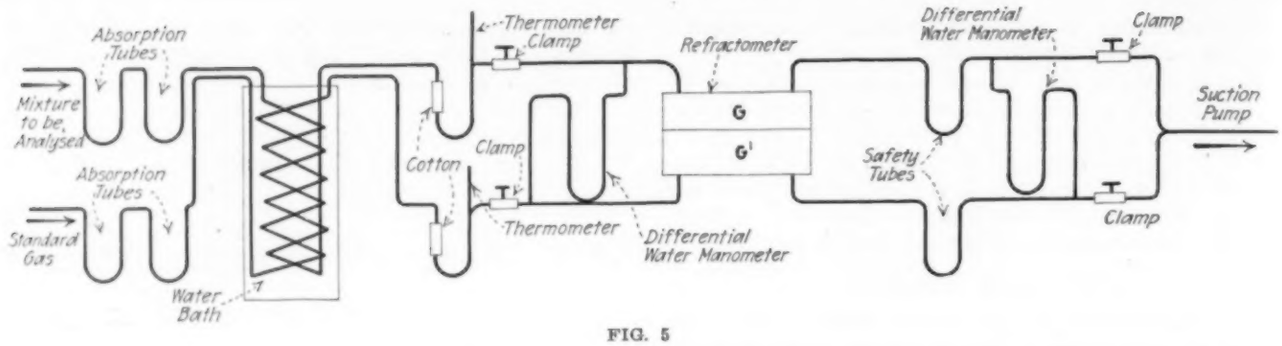


FIG. 5

mixture and that of the constituent taken as standard, i.e., to the displacement of the micrometer screw.

This proportionality is easily verified experimentally. Thus, taking pure air as the standard gas and as the gas to be studied, the mixtures air-carbon dioxide, air-alcohol, etc., the results shown in Table I were obtained.

Precision of the Results

In the value $p_2 = d_2 a \dfrac{N'' - N_1'}{N_2 - N_1}$ errors can be made on the factors $N'' - N_1'$, $N_2 - N_1$, d_2 and a. The errors on d_2 and a are practically negligible. Experiments have shown that the error made when bringing the two central bands into alignment is not more than 1×10^{-7} in the index difference. The error in p_2 varies with the difference $N'' - N_1'$; $N_2 - N_1$ is known within a limited precision.

Table II gives examples of the precision reached with different gases mixed with air, assuming $N'' - N_1'$ known to $\pm 1 \times 10^{-7}$. Table III gives the indices of refraction of some gases.

TABLE II—PRECISION OF THE RESULTS OBTAINED IN THE ANALYSIS OF MIXTURES OF AIR WITH SOME GASES

Gas Mixed with Air	Error on p_2, Grams per cu.m.	Gas Mixed with Air	Error on p_2, Grams per cu.m.
Nitrogen	24	Acetone	0.3
Oxygen	5	Ordin. ether	0.3
Carbon monoxide	3	Ethyl alcohol	0.3
Water	2	Methane	0.5
Carbon dioxide	1		

TABLE III—INDICES OF REFRACTION OF SOME GASES

Gas	Index of Refraction	Gas	Index of Refraction
Air	1.0002926	Sulphur dioxide	1.000660
Nitrogen	1.0002978	Acetone	1.001079
Hydrogen	1.0001390	Benzene	1.001691
Oxygen	1.000272	Ordin. ether	1.001535
Ammonia	1.000377	Ethyl alcohol	1.000881
Carbon monoxide	1.0003342	Methane	1.0004438
Carbon dioxide	1.0004502	Ethane	1.0007528
Water	1.000257	Pentane	1.001701
Chlorine	1.000769		

The absolute error in N_1 and N_2 is of the 10^{-6} order, but the difference $N_2 - N_1$ varies in appreciable proportion. Thus it is 52×10^{-7} for nitrogen and air, 1576×10^{-7} for carbon dioxide and air, 12420×10^{-7} for ether and air, etc. It follows that:

In the analysis of a mixture in which the amount of one of the constituents is small, the precision of the results depends solely on the precision of the micrometer screw readings.

In the analysis of a mixture in which both constituents are in about the same proportion, the precision of the results depends equally on the precisions of the readings and of that of their individual indices of refraction.

In this last case it is advisable not to use the formula $p_2 = d_2 a \dfrac{N'' - N_1'}{N_2 - N_1}$, but to standardize the apparatus by comparison with chemical analyses.

Differences of pressure up to $\pm$ 5 mm. of water and of temperature up to $\pm$ 0.1 deg. C. of the gases in the chambers G, G' can be considered as having practically no influence on the error in the final result.

Arrangements for Industrial Gas Analyses

Figs. 5 and 6 show convenient arrangements for the industrial analyses of gases by Lord Rayleigh's interferometer. The water bath brings the gases to the same temperature. The equality of pressure of the gases is obtained in the first arrangement (Fig. 5) by adjusting the clamps and in the second case (Fig. 6) by putting the gas chambers G and G' in communication with the atmosphere through the 3-way stopcocks.

The first arrangement is preferable when frequent readings are required, say every 5 seconds. The second arrangement gives more accurate results, and is simpler and easier to handle, but the readings can be taken only every 15 to 20 seconds.

Analysis of Ternary Gas Mixtures

If p_1, p_2, p_3 are the weights of the constituents contained in the unit volumes of the mixture; d_1, d_2, d_3 their relative densities, N_1, N_2, N_3 their refraction in-

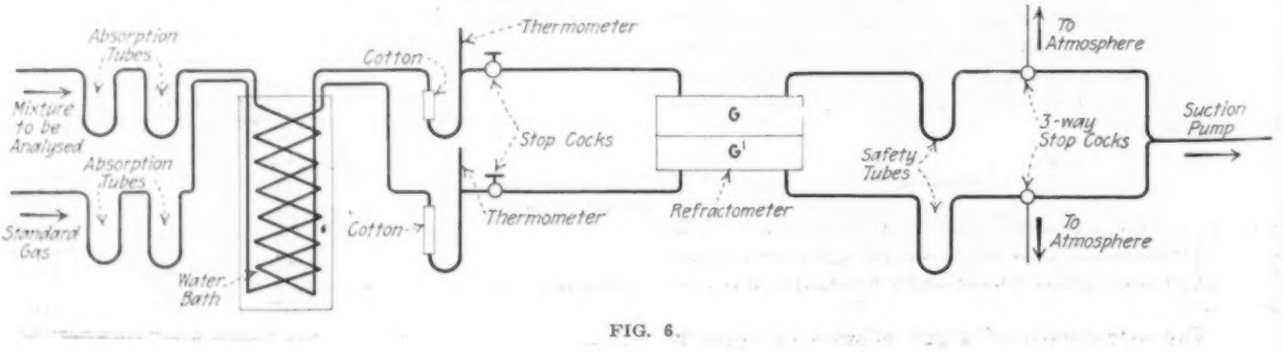


FIG. 6.

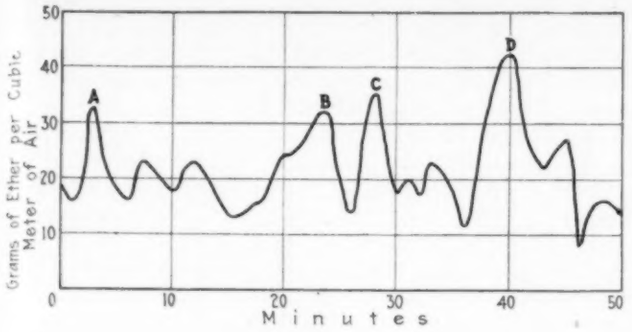


FIG. 7

dices, the relation (3) given for binary gas mixtures becomes

$$N'N'_1 = (N_2 - N_1)\frac{p_2}{d_2 a} + (N_3 - N_1)\frac{p_3}{d_3 a} \qquad (4)$$

Here there is one relation in which there are two unknown factors, p_2 and p_3. A second relation is required. This can be obtained by absorbing one of the reagents in the absorption tubes, but the operation is impracticable. It can therefore be stated *for mixtures composed of more than two gases, the interferometric method does not present any advantage over the standard volumetric or gravimetric methods.*

In case one of the constituents of a ternary gas mixture is not taken into consideration the problem reverts to the analysis of a binary mixture.

An illustrative example of the value of the interferometric method in the analysis of binary gas mixtures is best shown by the diagram, Fig. 7. This gives the results obtained by interferometric analyses of an ether-air mixture from a nitrocellulose powder factory. The variations in the ether content, although very rapid, are easily recorded. No known chemical method could give similar or nearly similar reliable results.

Calculation of Hydrometer Degrees, Gravities and Weights With the Slide Rule

By Wallace Savage

IN THE two hundred and forty-odd years since Robert Boyle designed the first hydrometer, it almost seems that a new modification has made an appearance on an average of once a year. Fortunately the styles that have disappeared have accounted for about two centuries of this time. The remaining twoscore must have some raison d'être to account for their survival. No doubt the hydrometer is the simplest weighing device existent from a mechanical construction point of view. It is based on the principle of Archimedes, viz., *a body immersed in a liquid loses, by virtue of the surrounding particles, a weight equal to that of the liquid displaced by it.*

Archimedes was led to the discovery of this principle while trying to determine whether the new crown of the king of Syracuse was pure gold as represented by the goldsmith or not. Finding that the crown did not bear the 19.3 ratio to water as should be exhibited by pure gold, and was considerably less, Archimedes was able to demonstrate the fraud conclusively. Boyle's problem had a certain similarity. In 1675 counterfeit guineas were quite prevalent in England and the first hydrometer was devised by him with a clip at the base so that the guinea to be inspected could be suspended from the float. Counterfeit guineas were always too light to sink the float to the indicator mark.

Classes of Hydrometers

Up to the present time there have been two types of hydrometers—constant volume and constant weight. The former is used mostly for determining the density of solids and is not of industrial importance. Nicholson's apparatus is the classical one. The constant weight hydrometer is used for gravity determinations of liquids and, next to the thermometer, it is the most widely applied instrument in the manufacturing industries. Because of the importance of temperature corrections, a mercury thermometer is often built into the spindle and the instrument is then called a thermo-hydrometer.

Constant weight hydrometers have four types of scales:

Density hydrometers, indicating density of a specified liquid, at a stated temperature, in specified units.

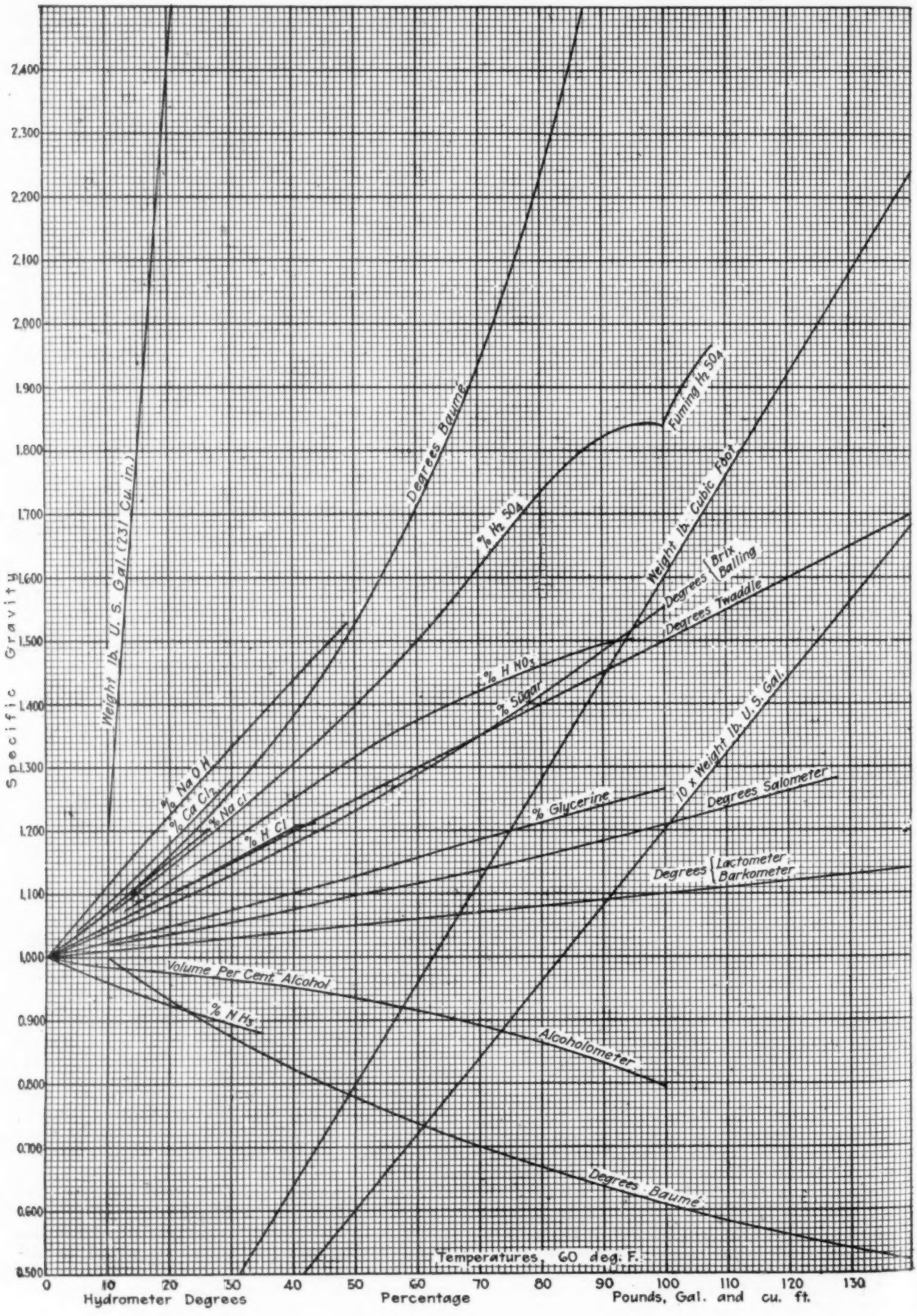
Specific-gravity hydrometers, indicating the relative density of a specified liquid at a stated temperature to water at a stated temperature.

Per cent hydrometers, indicating, at a stated temperature, the percentage of a specified material in its aqueous solution.

Arbitrary scale hydrometers, indicating, at a stated temperature, degrees having an arbitrary but fixed relation to specific gravity.

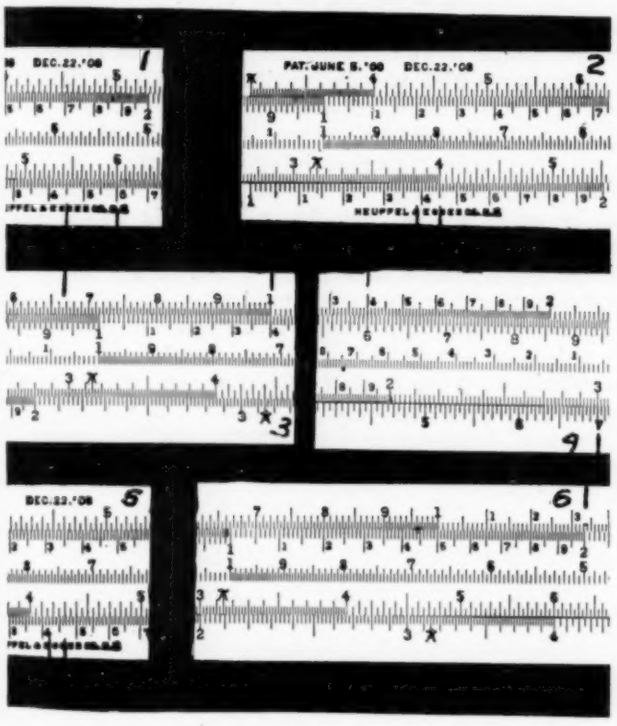
Density and specific-gravity hydrometers need no elucidation. They did not find favor with the old-time instrument makers partly because they have a variable length scale which is difficult to graduate on the stem of the instrument. Halves, quarters, eighths, sixteenths and thirty-seconds or submultiples of 360 were the only paths beaten into the early mathematical instrument realm. To the average mind of the centuries prior to our own, decimal fractions were not even to be considered. Without doubt there is much virtue in the simple integer "degree" scales. For instance take 66 deg. Baumé oil of vitriol. Who would prefer to memorize 1.8354 sp.gr. or try to teach it to acid plant workmen? No doubt the per cent hydrometer is the instrument of the future. However, some substances such as sulphuric acid do not lend themselves well to this type of instrument. In an accompanying chart, several degree scales, solution gravities, etc., have been plotted. From these curves and lines, all the equivalents can readily be obtained.

The first thing to be noticed is that the salts such as sodium hydroxide and the chlorides of sodium, hydrogen, calcium give approximately straight lines and are thus more or less additive. The oxy-acids, such as nitric and sulphuric, exhibit peculiar curves and, due to the compression of solvent, do not take on the expected increments in solution gravity corresponding to the increments in solute mass. Alcohol acts similarly, giving large shrinkages. Usually in the distillery trade, the term degree proof is used and is simply twice the volume per cent. Thus ethyl alcohol of 0.900 sp.gr., is 66 vol. per cent, 132 deg. proof, 25.4 deg. Baumé and weighs 7.5 lb. gal., 56.0 lb. cu.ft.


Specific Gravity
2.400
2.300
2.200
2.100
2.000
1.900
1.800
1.700
1.600
1.500
1.400
1.300
1.200
1.100
1.000
0.900
0.800
0.700
0.600
0.500
Weight lb. U. S. Gal. (231 Cu. in.)
Degrees Baumé
% H_2SO_4
Fuming H_2SO_4
Weight lb. Cubic Foot
Degrees Brix
Degrees Balling
Degrees Twaddle
% HNO_3
% Sugar
% NaOH
% $CaCl_2$
% NaCl
% HCl
% Glycerine
10 x Weight lb. U. S. Gal.
Degrees Salometer
Degrees Lactometer
Degrees Barkometer
Volume Per Cent. Alcohol
% NH_3
Alcoholometer
Degrees Baumé
Temperatures, 60 deg. F.
0 10 20 30 40 50 60 70 80 90 100 110 120 130
Hydrometer Degrees
Percentage
Pounds, Gal. and cu. ft.

Arbitrary Scale Hydrometer Moduli

With the exception of the Twaddle, Barkometer, Lactometer, etc., scales, the arbitrary scale heavier than water hydrometers of Baumé, Beck, Cartier, Gay-Lussac, Balling, Brix, Fischer, Greiner and Stoppani all fall under the formula Deg. $= M(S - 1) \div S$, where M has a special value for each scale. The former three are more simple, being expressed by the formula Deg. $= M(S - 1)$. The lighter-than-water scales follow logically, having the formula: Deg. $= M(1 - S) \div S$ in the case of all but the Baumé[1] and Cartier scales, where 10 and 10.7 are added respectively to the calculated degrees. See table opposite.



GRAVITY CONVERSIONS ON THE SLIDE RULE

1. 1.60 Specific Gravity = 54.4 Deg. BhU.S.B.S.: $\frac{54.4}{145} = \frac{0.6}{1.6}$
2. 40 Deg. BhU.S.B.S. = 1.381 Sp.Gr.: $\frac{40}{145} = \frac{0.381}{1.381}$
3. 20 Deg. BlU.S.B.S. = 0.933 Sp.Gr: $\frac{10(+10)}{140} = \frac{0.666}{0.933}$
4. 0.70 Sp.Gr. = 60 Deg. BlU.S.B.S.: $\frac{60(+10)}{140} = \frac{0.3}{0.7}$
5. 43 Deg. Bh Gerlach = 1.415: $\frac{43}{146.78} = \frac{0.415}{1.415}$
6. 1.666 Sp.Gr. = 133.2 Deg. Twaddle: $\frac{133.2}{200} = \frac{0.666}{1}$

Unfortunately the most prominent of the arbitrary scale hydrometers, the Baumé, has at least eight values of M. This is a considerable improvement since 1881, when Prof. Charles F. Chandler[2] found 23. In 1904, the U. S. Bureau of Standards adopted 145 and 140 as the moduli of the heavy and light Baumé scales. These are based on 60 deg. F. determinations. Most of the petroleum hydrometers manufactured by Tagliabue in use have a modulus of 141.5. The other heavier-than-water Baumé moduli are 144, 144.3, 145.83, 146.3 and 146.78, varying from 4 to 17.5 deg. C.

[1] Old Holland does not add 10.
[2] National Academy of Science, 1881.

The table below gives in the form of proportions the formulæ expressing the relation between specific gravity and hydrometer degrees. The six settings on the slide rule illustrate the application of these proportions with the light and heavy Baumé scales as well as the Twaddle scale. As American chemists will be concerned mainly with the U. S. Bureau of Standards Baumé scale, it should be noted that the value of the modulus is a function of the temperature. By determining the modulus, "m," at any temperature of a d degree liquid, degrees corrected for temperatures can be quickly calculated by setting $d : m :: D : M$.

HYDROMETER DEGREE SLIDE RULE FORMULAE

	Heavier Than Water	Lighter Than Water
Gay—Lussac	$\frac{D}{100} = \frac{S-1}{S}$	$\frac{D}{100} = \frac{1-S}{S}$
Cartier	$\frac{D+10.7}{126.1} = \frac{S-1}{S}$	$\frac{D+10.7}{126.1} = \frac{1-S}{S}$
Baumé, U. S. B. S.	$\frac{D}{145} = \frac{S-1}{S}$ (60°F.)	$\frac{D-10}{140} = \frac{1-S}{S}$ (60°F.)
Taglibue	.....	$\frac{D-10}{141.5} = \frac{1-S}{S}$ (60°F.)
"Old Holland"	$\frac{D}{144} = \frac{S-1}{S}$	$\frac{D}{144} = \frac{1-S}{S}$ (4°C.)
Gerlach	$\frac{D}{146.78} = \frac{S-1}{S}$	$\frac{D-10}{146.78} = \frac{1-S}{S}$ (17.5°C.)
Stoppani	$\frac{D}{166} = \frac{S-1}{S}$	$\frac{D}{166} = \frac{1-S}{S}$
Beck	$\frac{D}{170} = \frac{S-1}{S}$	$\frac{D}{170} = \frac{1-S}{S}$
Balling (not for sugar)	$\frac{D}{200} = \frac{S-1}{S}$	$\frac{D}{200} = \frac{1-S}{S}$
Brix, Fischer, Greiner } Not for sugar	$\frac{D}{400} = \frac{S-1}{S}$	$\frac{D}{400} = \frac{1-S}{S}$
Twaddle	$\frac{D}{200} = S - 1$	
Barkometer, Lactometer	$\frac{D}{100} = S - 1$	

The slide rule offers a most excellent medium for determining either an unknown modulus from values of D and S or either of the latter, when the two others are given. D can be determined to three significant figures, which is with as good a degree of accuracy as the best hydrometers can be read. Differences in the various Baumé scales are easily determined, as will be observed from the settings given. Some practice will be required in picking out the ratios $(S - 1)/S$ and $(1 - S)/S$ when calculating specific gravities from hydrometer readings. Adding and subtracting constants is also awkward at first. Temperature conversions should be practiced by setting 5 to 9 and reading the corresponding scales less 40. Thus 140 will be found opposite 252 on the scale and by reading 40 less, 100 deg. C. is read equivalent to 212 deg. F. The basis of this method of conversion is the fact that —40 deg. F. corresponds to —40 deg. C.

Weights per gal. or cu.ft. are obtained by setting S over 12 or 16 respectively. Thus 1 gal. of 100 deg. Bark. tanning extract has a sp.gr. of 1.100 and weighs 9.16 lb. One cu.ft. of 54.4 deg. Baumé sulphuric acid, sp.gr. 1.60, weighs 100 lb.

Determination of Maltose Conversions

By F. E. Coombs

IN THE technical production of maltose and maltodextrine, iodine solution is generally used as an indicator of completed process, but in the writer's experience this has been found highly unsatisfactory.

Its use is limited to establishing in a gelatinized starch solution, or suspension, the point where all of the "normal" starch has been altered; but it by no means shows what part of the starch has gone completely over into maltose when, as is oftenest the case, the desired product is to carry more or less dextrine along with the maltose, and most often some profitable object is attained by carrying a fixed percentage of dextrine and of maltose in the finished material. Further, if raw ground malt has been added to the cooked starch-mass in the converter, a certain amount of raw starch is introduced with it which, at conversion temperatures, is not gelatinized or hydrolized. This persists, and if the iodine reaction is relied upon the process is needlessly prolonged. Polarimetric methods are intricate and too slow for use as control of a going conversion.

Quick and Satisfactory Method

The subject of this paper is a quick and satisfactory technical method for the control of malt-conversions which the writer has found reasonably accurate, capable of use by an average attendant, and which will enable him to stop a conversion at any predetermined ratio of maltose to dextrine.

On starting the conversion and as soon as the contents of the tank are homogeneous, a sample is taken, through a fine brass gauze strainer, into a flask large enough to contain more than a filling for a hydrometer jar. The sample is cooled in the flask under a tap to a standard temperature and a spindle reading taken at that temperature. From a table later described and calculated for some desired balance of maltose-to-dextrine, there is then read off a number of cubic centimeters corresponding to a fixed weight—conveniently 10 g. —of the sample at the observed density, and this volume is then measured with a graduated pipette into a flask, made up to, say, 150 cc. with distilled water, well shaken, and a burette filled to zero with the diluted sample. From the burette a prescribed number of cubic centimeters is run into 10 cc. of freshly mixed, boiling Soxhlet solution and boiled for a minute or two. Should the added volume of dilute sample fail to reduce all of the copper, as indicated by the blue color remaining after the boiling in the clear upper portion of the test, then the conversion is known not to be completed to the required point and is allowed to go on.

Completion of the Test

During progress of the cook, these tests are repeated at intervals judged by the rate of disapparance of the blue color, until a final test shows its entire or almost complete absence, when the conversion is immediately stopped by admitting steam to an ample coil in the converter tank. A small bench near the converter is provided with the needed apparatus, including a rack carrying a series of 10-in. test tubes ready filled with 10 cc. charges of mixed Soxhlet solution. At this bench is posted a typed table showing the constants to be followed in making the tests, such tables being kept in readiness and separate ones made for each material change in the maltose-dextrine ratios that may be wanted from time to time.

Calculation of Tables

The calculation of the tables is simple and is based on the fact that, for practical purposes, the specific gravity influence of the two components, in solution, is the same for the same percentages contained. Each table has three columns, the first showing the range of densities B. in half degrees (or Brix in whole degrees) covering the maximum fluctuation of the converter liquors; a second column shows the number of cubic centimeters equal to 10 g. of a sample at the listed densities; the last vertical parallel column indicates the volume of diluted sample to be run into the Soxhlet tube from the burette, and which will just reduce the copper therein when the total solids are one-half, two-thirds, or whatever is desired in maltose content in the finished product in ratio to the dextrine remaining unconverted.

The test, including taking and cooling the sample, can be made in less than five minutes, is within the ability of any operative intelligent enough to trust with conducting a process kettle, and it will insure uniform composition of the conversion product.

It is recommended that the light provided for doing the reduction test should be a good incandescent (nitrogen-filled) lamp, as in that case the men are not confused in judging the color by changes of weather or alternation from day to night shifts, and once having caught the proper appearance of an exact reduction, this will not vary.

TABLE I—TABLE FOR MALTOSE CONVERTER CONTROL

(Total solids of finished product to contain 50 per cent maltose)

Per Cent Solids (Deg. Brix) Converter Liquor	Volume Converter Liquor = 10 g. cc.	Dilute Liquor From Burette cc.
13.0	9.5	18.6
13.5	9.5	17.9
14.0	9.5	17.5
14.5	9.4	16.8
15.0	9.4	16.2
15.5	9.4	15.6
16.0	9.4	15.1
16.5	9.4	14.6
17.0	9.4	14.2
17.5	9.3	13.8
18.0	9.3	13.5
18.5	9.3	13.1
19.0	9.2	12.8
19.5	9.2	12.5
20.0	9.2	12.2
20.5	9.2	11.8

The general formula for a table such as the one given would be

$$100\left(0.0807 \div \frac{\text{Sp. gr.} \times \text{Brix} \times ax}{150}\right) = y$$

In which

0.0807 = grams maltose to reduce 10 cc. Soxhlet solution.
Sp. gr. = Specific gravity of converter contents.
a = Per cent maltose desired in total solids, as a decimal expression.
$x = \frac{10}{\text{Sp. gr.}}$ = cubic centimeters of original converter liquor to be diluted to 150 cc.
and y = Cubic centimeters of diluted liquor to be delivered from burette into 10 cc. of Soxhlet solution, and which will just reduce the copper therein when the predetermined percentage of maltose has been reached.

If the table is to be based on a uniform measured volume of 10 cc. of original converter liquor, then, with the same constants as above, the formula becomes

$$100\left(0.0807 \div \frac{10 \text{ Sp. gr.} \times \text{Brix} \times a}{150}\right) = y$$

In the first column of Table I the usual range of densities of the converter liquor is covered, stated as degrees Brix, and assuming that the liquor has been strained carefully and cooled to not above 20 deg. C.

G. L. Spencer's "Handbook for Sugar Manufacturers," edition of 1906, carries a table of specific gravities parallel to degrees Brix, which has been used in the calculation of the table.

If, then, 10 g. be divided by the specific gravity corresponding to, say, 15 deg. Brix (1.061), 9.42 cc. will be found as the nearest equivalent volume, and can conveniently be measured out as 9.4 cc. for a working quantity, and in this way the second column of the table is derived. Having measured this volume and diluted it to 150 cc., each cubic centimeter will represent 0.06667 g. of the original converter liquor, and $0.06667 \times .15$ (decimal expression of the total solids) will give the weight of the original solids now contained in the diluted liquor, per cubic centimeter, or 0.01 g. And if 50 per cent of the total solids are to be maltose, each cc. of the diluted liquor should contain 0.005 g. maltose when conversion has progressed to the desired stage. And since each measured portion of Soxhlet solution corresponds to 0.0807 g. of maltose, then $\frac{0.0807}{0.005} = 16.14$ cc., or the volume required to be run from the burette to reduce all the copper of the Soxhlet solution. But the burette will not measure closer than 0.1 cc., and if 16.1 is taken, it will be found by retrogressive calculation that $\frac{0.0807}{16.1} = 0.0050124$ g. as the weight of maltese per 1 cc. of the diluted liquor. This weight divided by $\frac{(1.061 \times 9.4)\ .15}{150} = 0.5025$ plus.

In this case decimal errors have been cumulative in one direction, as only tenths of cubic centimeters can be regarded in measurements ordinarily. For this reason, 16.2 cc. is used in the table, and this figure, by the preceding calculation, will give 49.94 per cent maltose, which is close enough for factory purposes. Control tables of this nature must always be checked back and figures empirically altered to conform as nearly as possible to technical needs and the requirements of manipulation.

It is obvious that tables for this purpose may be calculated by taking a uniform volume of the converter liquor instead of a uniform approximate weight—for example, 10 cc.—and that in such a case only two columns are required, since the second one of the tables I have given might be omitted. And it is also clear that such tables will serve as well for the working of acid hydrolysis in dextrose conversion from starch.

San Francisco, Cal.

A Town for Sale

The War Department is offering for sale the town of Nitro, West Virginia, a complete industrial community embracing 737 manufacturing buildings housing accommodations for 20,000 persons and the utilities and civic improvements that constitute the conveniences of a modern city. Nitro, built by the Government at a cost of approximately $70,000,000, is the site of the second largest smokeless powder plant in the world. The bids, which must cover not only the powder plant and the other industrial units which were erected to prepare the ingredients essential to powder making, but the civic community as well, to which the United States also holds title, will be opened at 12 o'clock noon on Sept. 30, 1919, at the office of the Chairman of the Ordnance District Salvage Board, 1710 Market St., Philadelphia, Pa.

Synopsis of Recent Chemical and Metallurgical Literature

Uses of Water Power and Raw Materials in the Metallurgical and Chemical Industries in France.—In the May-June, 1918, issue of *La Houille Blanche* Mr. E. F. CÔTE described at length the bright side of the potential value of the Rhone waterfalls, and gave in conclusion a table on the water power and raw materials used in electrometallurgical and chemical industries. (See Table I.) In the September-October issue of *La Houille Blanche* Prof. GEORGES FLUSSIN, director of the Electrochemical and Metallurgical Laboratory of Grenoble, France, gave another table on the same subject. (See Table II.)

Both authors state that the figures are only approximate and that they vary somewhat with the apparatus used, the method of manufacturing and the composition of the raw materials. Abstracts of these tables are given as representing average French hydro-electric practice.

TABLE I—CONSUMPTION OF HYDRO-ELECTRIC POWER AND RAW MATERIALS IN SOME CHEMICAL AND METALLURGICAL INDUSTRIES (E. F. COTE)

Products	Per Ton of Manufactured Product: Kw.-Day (24 Hr.)	Raw Material Handled (Tons)	Raw Materials Handled per Kw.-Yr. (Tons)
Calcium carbide	180	2.5	4.5
Ferrosilicon, 50 per cent	300	3.0	3.3
Ferrosilicon, 80 per cent	650	4.0	2.0
Ferrochrome, 8 per cent	360	4.0	3.7
Ferromolybdemun	360	3.5	3.2
Ferrotungsten	325	3.0	3.0
Usual aluminum	950	4.0	1.3
Amorphous carborundum	700	3.0	1.4
Electrolytic soda	60	6.0	33.4
Electric steel	12	1.2	34.0
Zinc (by electric furnace)	200	5.0	8.0
Zinc (by electrolysis)	180	7.0	13.0
Lead and antimony	120	4.5	12.5
Nickel (from matte)	180	4.0	7.0
Copper (15 per cent ore)	250	9.0	12.0
Copper (refining)	4	1.5	90.0
Carbon sulphide	85	2.4	9.4
Opaque glass products	200	2.5	4.0
Manufacture of electrodes	250	2.5	3.3

TABLE II—CONSUMPTION OF HYDRO-ELECTRIC POWER AND RAW MATERIALS IN SOME CHEMICAL AND METALLURGICAL INDUSTRIES (PROF. GEORGES FLUSSIN)

Products	Per Kw.-Day (24 Hr.): Kilograms Obtained	Kilograms of Principal Raw Materials Used	Consumption per Ton of Manufactured Product: Kw.-Day (24 Hr.)	Raw Materia
Phosphorus	1.1	14 to 22	909	13 to 20
Chlorine	6.0	27	167	4.5
Caustic soda	6.6			
Sodium perchlorate	5 to 7	4.7 to 6.6	200 to 143	0.95
Carborundum	2.8	10	357	3.6
Artificial corundum	9 to 11	18 to 22	111 to 91	2.0
Calcium carbide	5.5 to 6	9 to 10	182 to 167	1.75
Synthetic nitric acid	1.3 to 1.5	...	770 to 667	...
Calcium cyanamide	45	36	22	0.8
Sodium	1.2	3.1	834	2.6
Aluminum	0.8 to 0.9	2.5	1250 to 1111	3.0
Synthetic pig iron	24 to 30	36 to 38	42 to 33	1.3
Steel, solid charge	22	27	45.5	1.3
Steel, liquid charge	120	150	8.3	1.3
Electrolytic iron, with rotating cathode	6	7	167	1.1
Electrolytic iron, with fixed cathode	23	25	43.5	1.1
Ferrosilicons: 10 to 12 Si.	9.2	14.3	109	1.55
Ferrosilicons: 25 to 30 Si.	5.8	11.0	172	1.90
Ferrosilicons: 45 to 50 Si.	3.0	8.7	333	2.90
Ferrosilicons: 70 to 80 Si.	1.4	6.0	714	4.30
Ferrosilicons: 90 to 95 Si.	1.0	6.4	1000	6.40
Ferro-manganese: 18 to 20 Mn.	15	27	67	1.80
Ferro-manganese: 70 to 75 Mn.	6	19	167	3.15
Ferrochrome: 10 per cent C.	3.5	10	286	2.90
Ferrochrome: 1 per cent C.	1.8	14	555	4.05
Ferrotungsten	2.5 to 3.5	7	400 to 286	2.7
Silico-manganese: 10 Si-20 Mn.	7.5	16.6	133	2.2
Silico-manganese: 10 Si-70 Mn.	4.6	11.4	217	2.5
Silico-manganese: 25 Si-50 Mn.	3.0	8.0	333	2.7

Natural and Industrial Resources of France, Germany, Great Britain and Ireland, the United States and the World for 1913.—In a series of articles published by *L'Industrie Chimique* during the months of May to December, 1918, AGRICOLA passes in review the situation of the natural and industrial resources of France, Germany, Great Britain and Ireland, the United States and the world in 1913. The data given form a very valuable source of information on the economic status before the war and no doubt will serve as a basis of comparison in the history of the industrial progress during the pre-war and post-war times. It is noteworthy that the United States produced about 60 per cent of the totals of cereals, cotton, oil, copper, aluminum; about 40 per cent of coal, pig iron, steel, zinc; about 30 per cent iron, lead, silver; about 20 per cent gold, etc., while its population was only about 15 per cent of the world's total.

TABLE I—COMPARATIVE DATA ON ECONOMIC, FINANCIAL AND INDUSTRIAL RESOURCES, 1913

	France	Germany	Great Britain and Ireland	United States	World
Area sq. miles	204,090	208,830	120,979	3,507,640	52,000,000
Area under cultivation, sq.mi.	132,600	132,600	74,100	772,200	.....
Forests, sq.mi.	38,400	33,700	4,860	768,300	.....
Population	40,000,000	70,000,000	48,000,000	105,000,000	1,650,000,000
Industrial employees	6,260,000	10,853,000	.....	7,000,000	.....
Coal mining industry employees	199,000	611,000	1,069,000	723,000	.....
Chemical industry employees	33,650	220,000	120,000	149,339	.....
Engineers	.....	24,500	.....	.....	.....
Chemists	2,500	30,000	5,000	18,000	.....
National wealth (million dollars)	68,000	82,600	86,600	223,000	1,940,000
Revenues (million dollars)	6,800	10,200	11,640	29,100	194,000
Taxes (million dollars)	970	776	970	1,160	.....
Debt (million dollars)	6,130	4,760	3,380	1,060	.....
Army expenses (million dollars)	285	315	139	.....	1,555
Navy expenses (million dollars)	106	103	239	.....	778
Imports (million dollars)	1,650	2,600	3,810	1,770	.....
Exports (million dollars)	1,335	2,440	2,600	2,330	.....
Total commerce (million dollars)	2,985	5,040	6,410	4,110	39,800
Railways, miles	31,620	39,600	22,320	236,000	621,400
Merchant marine (net tons)	1,519,000	3,154,000	11,879,000	7,714,000	40,000,000
Steam motive power (hp.)	3,551,000	8,264,000	11,700,000	22,240,000	102,000,000
Hydraulic motive power (hp.)	600,000	445,000	80,000	2,000,000	13,000,000
Factories of chemical products	535	86,999	.....	2,856	.....
Recuperating coke ovens	2,000	30,000	7,000	8,500	.....
Blast-furnaces	112	309	331	206	.....
Spindles for cotton	7,400,000	11,400,000	56,000,000	31,500,000	145,000,000
Cotton weavers' looms	110,000	230,000	741,000	633,000	.....

TABLE II—COMPARATIVE PRODUCTION OF SOME OF THE MAIN INDUSTRIAL COMMODITIES, 1913—TONS

	France	Germany	Great Britain and Ireland	United States	World
Coal	40,500,000	177,000,000	260,000,000	464,000,000	1,150,000,000
Lignite	793,000	87,000,000	.....	.....	.....
Iron ores	23,250,000	28,600,000	16,250,000	59,400,000	140,770,000
Pyrites	270,000	225,000	11,000	360,000	7,000,000
Phosphate	335,000	.....	9	3,202,600	7,500,000
Salt	1,150,000	2,994,000	2,083,000	3,077,000	15,455,000
Petroleum	.....	150,000	.....	38,500,000	57,920,000
Gas (millions cu. m.)	1,350	2,770	5,550	5,770	22,000
Coke	2,900,000	32,168,600	20,000,000	40,000,000	90,000,000
Pig iron	5,310,000	19,310,000	10,650,000	31,461,600	80,000,000
Steel	4,635,000	17,615,000	7,790,000	31,800,000	.....
Zinc	63,500	277,000	58,000	308,500	975,000
Copper	13,000	37,500	68,000	527,600	1,005,900
Lead	53,000	181,000	29,000	386,700	1,185,000
Aluminum	18,000	3,000	7,500	22,500	68,200
Tin	500	12,410	18,350	.....	118,200
Sulphuric acid	875,000	1,600,000	1,150,000	2,200,000	10,500,000
Superphosphates	1,920,000	1,818,700	820,000	3,248,000	12,500,000
Ammonium sulphate	68,500	550,000	432,000	155,000	1,300,000
Sodium carbonate	350,000	550,000	750,000	675,000	3,500,000
Potash (K_2O)	6,000	1,100,000	.....	8,500	1,126,100
Beet sugar	800,000	2,738,000	.....	700,000	9,000,000
Alcohol (hectoliters)	3,100,000	3,750,000	1,193,000	3,650,000	22,900,000
Benzol	12,000	250,000	80,000	90,000	500,000
Cotton	.....	.....	.....	3,210,000	4,750,000
Wool	40,000	20,000	70,000	140,000	1,285,000
Cement	2,300,000	7,200,000	.....	15,050,000	35,000,000
Woodpaste	90,000	600,000	.....	2,600,000	6,000,000
Cellulose	.....	600,000	.....	1,600,000	3,500,000
Soaps	.....	.....	300,000	800,000	.....

TABLE III—COMPARATIVE CONSUMPTION OF SOME OF THE MAIN INDUSTRIAL COMMODITIES, 1913—TONS

	France	Germany	Great Britain and Ireland	United States	World
Coal	59,000,000	140,750,000	175,000,000	459,500,000	1,150,000,000
Lignite	795,000	88,145,000	120	.....	.....
Iron ores	14,600,000	42,500,000	22,750,000	60,750,000	141,000,000
Pyrites	700,000	1,220,000	810,000	1,300,000	7,000,000
Phosphates	1,250,000	1,190,000	535,000	2,120,000	7,500,000
Petroleum	420,000	750,000	530,000	.....	58,000,000
Coke	5,500,000	26,350,000	.....	37,100,000	90,000,000
Pig iron	5,400,000	18,650,000	9,730,000	30,000,000	80,000,000
Zinc	81,000	232,000	175,700	313,000	975,000
Copper	95,000	225,800	159,400	321,900	1,000,000
Lead	99,000	229,700	199,400	358,200	1,200,000
Aluminum	3,000	12,600	5,000	22,500	70,000
Tin	7,400	18,300	18,400	48,000	120,000
Min. fertilizers	2,850,000	5,700,000	1,160,000	6,000,000	27,000,000
Ph. fertilizers	1,875,000	4,206,000	910,000	4,870,000	12,500,000
Am. sulphate	95,000	400,000	100,000	250,000	1,300,000
Dyes	9,500	15,000	19,000	26,000	125,000
Sodium nitrate	322,115	774,320	143,190	635,905	2,785,000
Potash (K_2O)	40,437	604,283	17,480	248,294	1,125,000
Sugar	750,000	1,615,000	1,870,000	3,350,000	18,500,000
Paper	560,000	1,400,000	1,215,000	.....	10,000,000
Rubber	16,000	21,000	15,000	90,000	200,000
Cotton	250,000	384,245	302,281	1,192,300	4,750,000
Wool	189,000	214,000	327,600	214,200	1,285,000

TABLE IV—COMPARATIVE DATA ON THE VALUES OF SOME OF THE MAIN INDUSTRIAL COMMODITIES—1913

(In Million Dollars)

Industries	France	Germany	Great Britain and Ireland	United States	World
Food	2,820	4,560	3,390	7,770	38,800
Textile and tinctorial	845	974	1,584	1,846	8,660
Rubber	90	134	116	349	776
Mining	156	534	642	2,020	.....
Metallurgical (except precious metals)	136	388	194	866	1,940
Mineral fertilizers	49	116	27	136	582
Gas	53	105	214	223	835
Fuel	156	866	680	2,450	4,850
Acids	12	23	14	19.4	97
Alkalis	10	19	23	19.4	87
Lime and cement	29	93	.....	233	485
Leather	444	277	139	169	.....
Paper	49	78	68	156	582
Glass	39	58	.....	97	.....
Ceramics	30	49	.....	165	.....
Soaps	49	58	58	156	.....
Dyes	4	58	2	3.5	78
Pharmaceuticals	3	10	8	.....	24.3
Synthetic perfumes	3	6	.....	.....	12.6
Pyroligneous products	3	3	0.2	10	19.4

The Rubber Industry.—While the United States, as a result of intensive development of resources within its borders, materially reduced its dependence upon foreign sources of raw material during the war, it is well to remember that there are certain natural products which, for geographic reasons, must be secured from abroad. Chief among these is rubber, and the following tables[1] show the magnitude of our dependence.

The United States in 1917 consumed about 75 per cent of the rubber used in the world, as shown by Table I.

TABLE I—THE CONSUMPTION OF CRUDE RUBBER
(Long Tons)

Year	United States	Great Britain	France	Germany	Italy	Total
1910	42,210	20,455	3,799	13,775	2,201	82,440
1911	38,475	16,736	5,398	15,281	2,691	78,581
1912	52,964	18,724	4,633	15,643	3,872	95,836
1913	52,179	25,276	6,500	15,500	2,000	101,455
1914	61,251	18,549	5,000	11,000	4,000	99,800
1915	96,792	15,072	10,770	6,000	6,580	135,214
1916	116,477	26,760	14,685	3,000	8,552	169,474
1917	177,088	25,983	17,000	2,000	6,946	229,017

During 1917 Far Eastern plantations produced about 79.5 per cent of the world's supply of crude rubber; the British colonies turned out approximately 80 per cent of this, or 63 per cent of the total production of the world. The only American possession suitable for the growing of rubber is the Philippines, and they produced the insignificant total of 147 tons in 1917, or sufficient to last one of the large American manufacturers about one day.

Table II shows the world's production of crude rubber from 1900 to 1919, inclusive, the quantities being given in long tons (2240 pounds), and the statistics for plantation and Brazil rubber being given separately.

TABLE II—PRODUCTION OF CRUDE RUBBER

Year	Plantation	Brazil	Other Kinds	Total
1900	4	26,750	27,136	53,890
1901	5	30,300	24,545	54,850
1902	8	28,700	23,632	52,340
1903	21	31,100	24,829	55,950
1904	43	30,000	32,077	62,120
1905	145	35,000	27,000	62,145
1906	510	36,000	29,700	66,210
1907	1,000	38,000	30,000	69,000
1908	1,800	39,000	24,600	65,400
1909	3,600	42,000	24,000	69,600
1910	8,200	40,800	21,500	70,500
1911	14,419	37,730	23,000	75,149
1912	28,518	42,410	28,000	98,928
1913	47,618	39,370	21,452	108,440
1914	71,380	37,000	12,000	120,380
1915	107,867	37,220	13,615	158,702
1916	152,650	36,500	12,448	201,598
1917	204,251	39,370	13,258	256,879
1918*	210,000	38,000	12,000	260,000
1919*	240,000	38,000	12,000	290,000

*Estimated.

Indications are that plantations will henceforth furnish an increasing proportion of the world's supply of crude rubber. The difficulties of producing wild rubber in sufficient quantities in Brazil and other districts, together with its high cost of production and the superior, clean condition of plantation rubber, render the gathering of wild rubber disadvantageous compared with plantation rubber. It is said that the cost of production of plantation rubber averages approximately 25c. gold per lb. f.o.b. Far East, whereas Up River fine cannot be produced profitably under 55c. per lb. f.o.b. Brazil.

It is notable that 76 per cent of planted acreage of plantation rubber is owned by British capital, and 2.8 per cent by American capital, according to best available authorities, as shown by Table III.

TABLE III—OWNERSHIP OF PLANTATIONS

Plantation Interests	Acreage	Per Cent
British	1,513,576	75.9
Dutch	260,000	13.0
French and Belgian	100,000	5.0
American	55,000	2.8
German	3,400	0.2
All other	63,577	3.1
Total	1,995,553	100.0

The 55,000 acres planted and controlled by American capital comprise the estate of the General Rubber Co., in Sumatra. American interests have also recently acquired 40,000 acres of undeveloped land in Sumatra. A very limited area is also planted to rubber in Mindanao, Philippines.

A graphic idea of the growth of the plantation rubber industry may be derived from Table IV, giving the estimated acreages in bearing, number of trees, production, number of pounds per acre, and the percentage of increase for the years 1900 to 1922, inclusive. The estimates of acreage in bearing for 1920, 1921 and 1922 are based upon present planted acreage, additional areas of which will become productive.

TABLE IV—GROWTH OF PLANTATION RUBBER INDUSTRY

Year	Estimated Acreage in Bearing	Tons[2]	Increase, Per Cent.	Lb. per Acre Planted	Lb. per Acre In Bearing
1900	.....	4	...	...	...
1901	.....	5	25	...	...
1902	.....	8	60	...	...
1903	.....	21	162	...	...
1904	.....	43	104	...	...
1905	.....	145	237	3	...
1906	.....	510	251	5	...
1907	.....	1,000	96	5	...
1908	.....	1,800	80	7	...
1909	.....	3,600	100	11	...
1910	93,205	8,200	127	20	197
1911	237,240	14,419	75	26	136
1912	402,912	28,518	98	44	158
1913	345,385	47,618	66	66	195
1914	681,355	71,380	47	92	234
1915	885,079	107,867	51	133	273
1916	1,200,407	152,650	41	183	280
1917	1,448,033	204,251	34	229	316
1918	1,611,124	.....	...	...	...
1919	1,727,820	.....	...	...	...
1920	1,729,795	.....	...	...	...
1921	1,915,553	.....	...	...	...
1922	1,995,553	.....	...	...	...

Rubber is perhaps the only important staple which has not experienced an increase in price during the period of the world war. The reason is at once apparent from a study of the figures given in Table IV. Large acreages, planted years before, began to bear during the war period, so that production not only kept pace with the increasing demand, but actually exceeded it, resulting in lower prices. Table V shows the downward trend of the price of crude plantation hevea, first latex crêpe, in the New York market.

TABLE V—PRICE OF CRUDE PLANTATION RUBBER[3]

	Dollars per Lb.			
	Jan.	Apr.	July	Oct.
1913	1.10	0.95	0.70	0.52
1914	0.56	0.63	0.55	0.61
1915	0.86	0.62	0.63	0.59
1916	0.92	0.82	0.58	0.61
1917	0.80	0.80	0.67	0.63
1918	0.57	0.60	0.63	0.59
1919	0.55	0.49	0.40	....

[3]*Commerce Monthly* (National Bank of Commerce, New York), September, 1919

A fraction over 66 per cent of all rubber plantations are situated in British colonies, so that Great Britain exercises both political and financial control over the supply of this important raw maaterial. Of the total acreage under British control, 807,491 acres are in the Federated Malay States and Johore, 159,500 acres in the Straits Settlements, 251,500 in Ceylon, 41,820 in South India, 29,880 in British Borneo, 26,390 in British Burma, and 5000 in the South Sea Islands. Under

[1]Commerce Reports, Aug. 1, 1919, pp. 668-671; Crude Rubber Prices, by Isador Lubin, Price Bulletin No. 30, War Industries Board (reprinted in *India Rubber World*, Sept. 1, 1919, pp. 685-688).

the Dutch flag there are 352,455 acres in Sumatra, 238,830 acres in Java, and 10,100 acres in Dutch Borneo, giving the Netherlands political control over 49 per cent of the total world acreage in rubber plantations. France controls 10,000 acres in Cochin China, and the share of all other countries amounts to 62,577 acres. An almost unlimited area of desirable land for rubber plantations is yet available for development in Sumatra and Borneo; but such is not the case with the Malay Peninsula, Ceylon and Java.

The only place on American soil where conditions have been found favorable to rubber growing is the Philippine Islands, where about 147 tons were produced in Mindanao in 1917, but owing to an insufficient supply of good cheap labor (our Government prohibits the importation of Chinese coolies) and Government restriction limiting the amount of land which corporations can own to 2500 acres, the investment of American capital has been restricted and discouraged.

Metallurgical Calculations.—ADOLPH BREGMAN gives in the August, 1919, issue of *The Metal Industry*[1] an interesting note on the causes of inefficiency of melting appliances, with special reference to an oil-fired furnace. He illustrates by an example how this can be eliminated, and dwells on the necessity of preliminary calculations for an appropriate furnace. "It is an old story that it is far cheaper to change the plant on paper before it is built than after."

The data to be figured out for a given furnace which has to perform a given work are: The amount of heat needed, which is to be expressed in amount of fuel, and the air required for efficient combustion. From these data to determine the best adaptable conditions for efficient performance of the installation.

To take a definite problem:

Given a furnace which must melt 2000 lb. of copper; 4 heats per 8 hours; charging and tapping time ½ hr. per heat, i. e. 1½ hr. for actual melting time.

The theoretical heat necessary to melt a charge is given by

$$\text{B.t.u.} = A \times B \times (T_1 - T)$$

in which A = number of pounds of metal
B = specific heat of the metal
T = temperature of the metal before charging
T_1 = temperature of the metal when ready to tap

For copper $A = 2000$, $B = 0.095$. With $T = 60$ deg. F. and $T_1 = 2700$ deg. F., we have

$$\text{B.t.u.} = 2000 \times 0.095 \times (2700 - 6) = 501{,}600$$

With a factor of safety, or with a furnace efficiency of x per cent, the actual heat units required will be $501{,}600 \div x$. The actual factor of safety is to be considered according to local conditions. With $x =$ say 15, the actual heat units required will be $501{,}600 \div 0.15 = 3{,}344{,}000$ B.t.u.

Using as fuel an oil of say 140,000 B.t.u. per gallon the amount required will be $3{,}344{,}000 \div 140{,}000 = 23.9$ gallons.

The time limit for a melt being 1½ hr., the consumption of oil per hour will be, say, 16 gal. The oil pump and burners must be carefully chosen for size and ease of adjustment. To burn the oil efficiently a well defined amount of air is required. The chemical reactions of combustion are:

$$\begin{array}{rcl} C + O_2 & = & CO_2 \\ 12 \quad 32 & & 44 \\ H_2 + O & = & H_2O \\ 2 \quad 16 & & 18 \end{array}$$

i.e., one part C requires 2.67 parts O and one part H requires 8 parts O.

The oxygen content of the air being 23.1 per cent by weight, the amount of air required will be: $2.67 \div 0.231 = 11.55$ lb. per lb. of C and $8 \div 0.231 = 34.64$ lb. per lb. of H. For practical purposes the average composition of fuel oil may be taken as 85 per cent C and 12 per cent H, the remainder being sulphur, nitrogen, etc., which need not be considered here. With this grade of oil the total amount of air per lb. of fuel is $A = (11.55 \times 0.85) + (34.64 \times 0.12) = 13.97$, say 14 lb.

Taking 7.5 lb. oil per gal., the theoretical weight of air required per gal. of oil is $7.5 \times 14 = 105$ lb. One lb. of air at sea level at 60 deg. F. is equivalent to 13.14 cu.ft., and 105 lb. corresponds to $105 \times 13.14 = 1379.7$, say 1380 cu.ft. This figure represents the theoretical volume of air necessary to burn 1 gal. of oil. In actual practice it takes from 10 to 20 per cent more air to do the work. In order to be quite safe, one should allow 2000 cu.ft. of free air at ordinary temperature for every gallon of oil to be burned. With 16 gal. of oil per hour, we need $2000 \times 16 = 32{,}000$ cu. ft., i. e., $32{,}000 \div 60 =$ say, 533 cu.ft. air per minute.

The blower must be of sufficient size to handle the capacity. There is no fixed oil or air pressure for all burners. This can be determined only by the needs of the particular burner used. A logical use of air and oil gages will solve this problem.

It is excellent practice to preheat the oil to a temperature of about 20 to 25 deg. below the flash point. When using heavy crude oil this is absolutely necessary. Air also should be preheated to the temperature of the oil. It must be remembered, however, that if the air is heated due allowance must be made for its expansion and the consequent dilution as regards the proportion of oxygen. This can always be calculated from the formula

$$W = 0.080728 \times \frac{P \times 491.6}{14.6963 \times T \times 459.6}$$

in which W = weight of cu.ft. of air
P = barometric perssure in lb. per sq.in.
T = temperature in degrees F.

In addition the air, especally at low pressure, loses much of its pressure if it has a long travel. It is best to eliminate all avoidable bends and elbows.

Recovery of Zinc From Low-Grade and Complex Ores.—The Bureau of Mines Salt Lake City Station has co-operated with the Department of Metallurgical Research of the University of Utah in studying the possibility of devising new processes for the recovery of zinc from ores. Certain ores too low grade or complex to permit of profitable treatment by the retort process have been the subject of the research reported in Bulletin No. 168, Bureau of Mines, by DORSEY A. LYON and OLIVER C. RALSTON. The work reported in this bulletin covers only the concentration of zinc ores and the hydrometallurgy of zinc. Sulphide and oxidized ores were studied. Investigation included concentration tests by gravity and flotation; chloridizing sulphate, oxidizing and mag-

[1] Adolph Bregman, "Metallurgical Calculations," *Metal Ind.*, vol. 17, No. 8, August, 1919, pp. 369-370.

netic roasting; acid and alkaline leaching; precipitation of the metal both electrolytically and chemically. Tests were made to determine the suitability of the ores to concentration by igneous and magnetic processes.

Acyclic and Saturated Cyclic Hydrocarbons.—The June 30, 1919, issue of *Comptes Rendus* contains the results of the work of Messrs. G. CHAVANNE and J. L. SIMON on the preparation and the critical temperature of dissolution in aniline of some acyclic and saturated cyclic volatile hydrocarbons contained in petroleum distillates. They have studied the following products: Acyclic carbides: normal pentane and isopentane, normal hexane and isohexane, synthetic isohexane. isopentane, heptane, and octane. Saturated cyclic carbides: cyclohexane, methylcyclohexane, the three dimethylcyclohexanes, cyclopentane and methylcyclopentane. They also state that the use of manganous carbonate as a catalytic agent has proved to be particularly efficient in the transformation of butyric, adipic and methyladipic acids into the corresponding acetones (*Compt. Rend.*, T. 168, No. 26, June 30, 1919, pp. 1324-1326).

Recent Chemical and Metallurgical Patents

Complete specifications of any United States patents may be obtained by remitting 5c. each to the Commissioner of Patents, Washington, D. C.

Manufacture of Manganese Steel.—SIR ROBERT HADFIELD of Westminster, England, has developed a high silicon manganese steel which, when heated to between 900 and 1050 deg. C. and then quenched in water, is particularly suitable for use in helmets, body shields and as protective armor for aircraft. Sheets of the following composition when toughened have been found of superior quality: Fe 84.08 per cent, C 1.04 per cent, Si 1.42 per cent, Mn 12.65 per cent, Cr 0.81 per cent. Aluminum may replace silicon up to about equal parts of each, and nickel, cobalt, vanadium, tungsten or titanium, or a combination of these elements, may be used to modify or improve the qualities of the alloy. (1,310,528, July 22, 1919.)

Chloroform From Carbon Tetrachloride.—The present invention relates to certain improvements in the process of manufacturing chloroform described by A. W. SMITH in U. S. P. 753,325. That process involved the separate production of carbon bisulphide and sulphur dichloride, the interaction of these substances to produce carbon tetrachloride and the reduction of carbon tetrachloride to chloroform by agitating with finely divided metallic iron in a suitable reaction vessel. The principal reaction taking place is that indicated by the following equation:

$$2CCl_4 + 2H_2O + 2Fe = FeCl_2 + Fe(OH)_2 + 2CHCl_3$$

The temperature during this reaction must, however, be carefully controlled, since, if allowed to rise, the chloroform is also reduced:

$$2CHCl_3 + 2H_2O + 2Fe = FeCl_2 + Fe(OH)_2 + 2CH_2Cl_2$$

At such higher temperatures, other decomposition products of carbon tetrachloride are also formed. The method first employed consisted in placing the mixture of carbon tetrachloride and water in a double-walled vessel provided with means for circulating water between the two portions of the shell so that the temperature could be kept at about 20 deg. C. Iron filings were then added in successive small portions. It was found, however, that, working at a temperature low enough to prevent the formation of appreciable quantities of dichlormethane, the speed of reduction was extremely slow. Using a higher temperature, the yield was considerably lower due to over-reduction and the possibility of over-reduction increased directly with the amount of chloroform present, so that it was impractical to reduce more than 50 per cent of the carbon tetrachloride. At this point, the temperature was raised and the mixture of CCl_4, $CHCl_3$, CH_2Cl_2, etc., distilled off, yielding in impure chloroform which had to be treated by an expensive process of fractional distillation.

HERBERT H. DOW and WILLIAM O. QUAYLE have found that many of these difficulties may be avoided by using diminished pressure so that the chloroform, as formed, distills off with a certain amount of CCl_4, which is easily separated in the condenser and returned to the reaction chamber. The rapid removal of the $CHCl_3$ from the reaction zone minimizes the opportunity for further reduction and consequently a higher temperature may safely be used, thus increasing the speed of the reaction. Furtherfore, all of the iron or other reducing agent may be added at one time. (1,311,329; assigned to the Dow Chemical Co.; July 29, 1919.)

Method of Removing Certain Impurities From Electrolytic Cells.—HUGH K. MOORE of Berlin, N. H., notes that the gelatinous compounds of calcium and magnesium which deposit in the interstices of the cathode and form on the diaphragm of an electrolytic chlorine cell may be decomposed by filling the anode compartment of the emptied cell with a dilute solution of lactic acid. This acid solution is fed continuously to the cell through the usual float valve, washing the soluble reaction products away from the diaphragm, the cell being by-passed during the operation. The acid forms water-soluble lactates of calcium and magnesium, and the 0.8 per cent solution recommended is not of sufficient strength to dissolve iron to any appreciable extent. (1,309,214, July 8, 1919; assigned to the Brown Co. of Berlin, N. H.)

Separation of Materials by Gravity.—RICHARD L. LLOYD of New York City finds that the slag losses of metals or of matte can be reduced fully one-sixth by specially designed forehearth. In this hearth the incoming material is conducted to the bottom of the hearth, and the slag, rising upward through the metal or matte, is washed of metal values. The entire contents of the hearth are also agitated, assisting in the recovery. (1,310,998, July 22, 1919; assigned to the Dwight & Lloyd Metallurgical Co. of New York.)

Automatic Tempering-Machine for Tools.—CLARENCE O. STEE and KARL H. KOLHEDE of Cerro de Pasco, Peru, take advantage of the fact that tool-steel heated above its critical temperature is non-magnetic in designing an automatic machine for tempering tools. The apparatus consists of an electromagnet arranged as the weight of a pendulum; when the steel is above the critical temperature the electromagnetic pendulum controls the support upon which the heated tool to be tempered is placed. As the tool cools, becoming magnetic, the electromagnet is attracted to the tool, swinging far enough to make a contact, which in turn energizes a second electromagnet. This magnet

releases the support which holds the tool, thereby dropping it into the quenching bath. The apparatus is designed primarily for tempering rock-drills. (1,311,722; July 29, 1919.)

Treatment of Ores for Production of Metal and of Potassium Compounds.—CHARLES CUTLETT of Staunton, Va., increases the recovery of potassium in a soluble form from iron blast-furnaces or from other blast-furnaces where the ore contains potassium compounds, by adding salt in small amounts to the charge. The addition of calcium fluoride also tends to produce a slag containing a smaller amount of potash. The volatilized potassium compounds, in this case the chloride, are recovered from the fume and dust by the usual methods. (1,311,043, July 22, 1919; assigned to the British Potash Co., Ltd., of London.)

Apparatus for Extracting Metals From Their Ores.—EDMUND S. LEAVER of Tucson, Arizona, uses sulphurous acid as a leaching agent, in a rotating drum of special construction, for treating ores which contain copper oxides or carbonates. The pulverized ores,

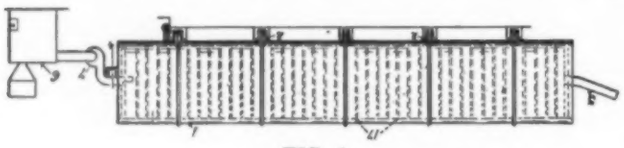


FIG. 1

in the form of pulp, containing about 5 per cent solids, is fed in at the opposite end of this drum from the SO_2 gases, and the flow of pulp and gases so controlled that the temperature of the discharged pulp is about 40 deg. C. At this temperature SO_2 is but slightly soluble

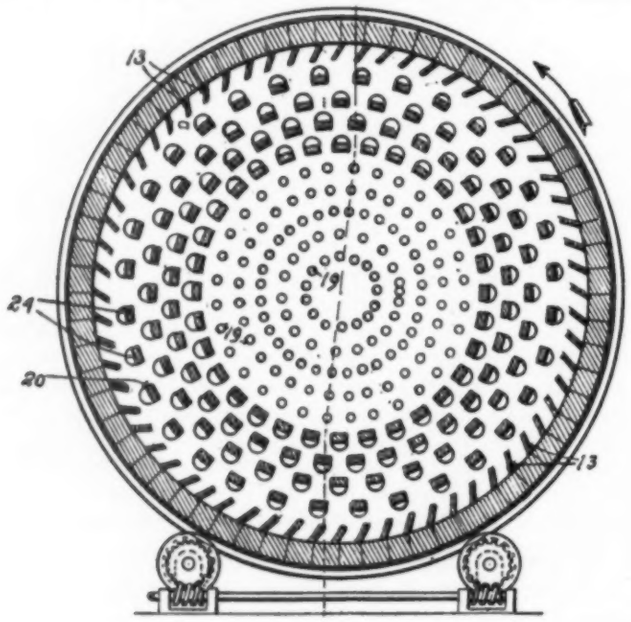


FIG. 2

in water. The gases carry an excess of oxygen, which oxidizes the sulphites to sulphates. The discharged pulp therefore contains the metals as sulphates and the exit gases are low in SO_2. The construction of the apparatus is shown in the figures. Fig. 1 is a longitudinal section. The gases from the sulphur burner or roasting furnace 6 are forced by fan 7 into the drum 1, which revolves on trunnions 2. The pulp is fed in and excess gases pass out through 3. The drum is fitted with partitions 17, perforated as at 19 and 20 in Fig. 2. Buckets 13 are provided on the inner circumference of the drum which lift the pulp and dump it on the slats, shown in section 24, by the revolution in direction of the arrow. (1,312,488, Aug. 5. 1919; one-half assigned to Chas. E. Van Barneveld.)

British Patents

Complete specifications of any British patents may be obtained by remitting 25c. each to the Superintendent, British Patent Office, Southampton Buildings, Chancery Lane, London, England.

Alkali Dichromates.—An alkali chromate solution is treated with carbonic acid and ammonia, preferably in the presence of ammonium carbonate in excess. Sodium bicarbonate is precipitated and removed, and the solution is then heated to remove ammonia and ammonium carbonate, and lime is added to produce calcium chromate, after which the liberated ammonia is removed by distillation. Niter cake is then added to produce alkali, dichromate and calcium sulphate, the latter being removed by filtration. (British Patent No. 122,172—1918. SOCIÉTÉ INDUSTRIELLE DE PRODUITS CHIMIQUES. Paris, March 19, 1919.)

Lead Chromate Pigments.—Basic lead acetate solution prepared from lead and acetic acid is purified by stirring with chalk or other agent that will absorb lead oxide, and the clear solution is used for the production of lead chromate pigments. Examples are given of the production of lemon chrome from purified lead acetate, acetic acid, sodium bichromate, sulphuric acid, alum and sodium sulphate, and middle chrome from purified lead acetate, acetic acid and sodium bichromate. (British Patent 123,841—1918. E. F. MORRIS, Holly Bank, Roby, near Liverpool. May 7, 1919.)

Albumens.—Soluble decolorized albumens are obtained from blood by first treating it for a considerable time will dilute acid, then adding hydrogen peroxide and allowing this to act for a considerable time, and finally neutralizing the added acid, all at ordinary temperature. Defibrinated blood is preferably used. The product may be evaporated to dryness in vacuo without losing its solubility. Instead of blood, blood cake or the like may be used. (British Patent 123,971—1918. A. J. L. TERWEN, 22 Aaksen Weimarlaan, and C. J. C. VAN HOOGENHUZZE, 8 Baustraat—both in Amsterdam. May 7, 1919.)

Treating Copper Waste. — Copper sweepings and scraps containing copper, zinc, iron, tin, antimony, silica, or other impurities, are roasted with not less than 15 per cent of common salt, silica being added if the amount present in the material to be treated is less than 25 per cent. The roasting is carried out in a two-part furnace comprising a muffle surmounted by a reverberatory furnace. Cupric or cuprous chloride is formed according to whether the roasting temperature is below or above 600 deg. C. The cupric chloride is recovered by leaching with dilute sulphuric acid or the cuprous chloride by volatilization and condensation. (British Patent 123,418—1918. C. C. CITO, 10 rue Henri Marichal, Bruxelles. April 16, 1919.)

Purifying Aluminum Salts.—Aluminum salt solutions, particularly the nitrate, are purified from iron by treatment with excess of amorphous or precipitated alumina, which may be prepared in situ by adding a soluble base to the solution, or an aluminum compound

such as calcined kaolin, clay, raw or calcined bauxite, labradorite, or anorthite. The treatment is preferably effected with heat and may be under pressure or otherwise. The solution may be stirred, or air may be blown through. Part of the iron may be precipitated by treatment with one of the minerals mentioned and the rest by precipitated alumina. The last traces of iron may be removed by ferrocyanide, the blue precipitate being absorbed in the first precipitate. If the iron is not in the ferric condition it is first oxidized. (British Patent 123,720—1918. NORSKE AKTIESELSKAB FOR ELEKTROKEMISK INDUSTRI, Norske Industri-Hypotekbank, 1, Bygdö Allé, Christiania. April 30, 1919.)

Alumina.—Kaolin, clay marl, halloysite shale and the like calcined at about 500 deg. C., preferably in a reducing atmosphere, and then treated with nitric acid, or with nitrogen oxides and steam or water. The aluminum nitrate solution is separated from the residue and treated to obtain alumina, e.g., by calcining or by precipitation with ammonia. (British Patent 122,623—1918. NORSKE AKTIESELSKAB FOR ELEKTROKEMISK INDUSTRI, Norske Industri - Hypotekbank, 1, Bygdö Allé, Christiania. Not yet accepted. March 26, 1919.)

Personal

Col. E. H. ABADIE has been appointed comptroller of the Division of Operations, U. S. Shipping Board, vice Mr. JOHN J. NEVIN, resigned.

Mr. J. F. BARTHOLOMEW has accepted the position as chief chemist with the Charlotte Chemical Laboratories, Inc., Charlotte, N. C., having formerly been chemical engineer for the Air Nitrates Corp., Muscle Shoals, Ala.

Dr. D. C. BYERS of the University of Washington has been appointed chief of the Division of Chemistry in the Bureau of Soils, Department of Agriculture, Washington.

Prof. H. C. COLES, who had charge of industrial chemistry at the College of the City of New York during the absence of Professor Moody, has resigned to accept a position as metallurgical expert with the Niles Tool Works Co., New York.

Dr. CHARLES H. HERTY, editor of the *Journal of Industrial and Engineering Chemistry*, sailed on Sept. 3 for Europe. Dr. Herty has been appointed by President Wilson to secure America's share of German dyes which by the terms of the Peace Treaty passed to the control of the Reparations Commission. Dr. Herty will endeavor to secure a six months' supply of vat dyes to fill the needs of consumers until vat dyes of American manufacture are on the market.

Mr. WALTER K. MALLETTE has been selected to head the engineering department of the Copper Queen Branch of the Phelps Dodge Corporaton and left San Francisco recently for Douglas, Ariz.

Mr. PAUL D. V. MANNING, formerly chemist with the nitrate division of the Ordnance Department, his last assignment being at the Fixed-Nitrogen Research Laboratory, American University, Washington, D. C., has accepted a position as electrometallurgist with the Chile Exploration Co., New York City.

Dr. CHARLES L. PARSONS, chief chemist of the Bureau of Mines, has resigned, and it is reported that he will enter private practice.

Dr. CHARLES L. REESE of the du Pont Company and Dr. H. S. MINER of the Welsbach Company, each received the honorary degree of Sc.D. from the University of Pennsylvania, this summer.

Dr. JAMES H. RANSOM resigned as director of the chemical department of Vanderbilt University, last May, and has accepted a position as research chemist with the Michigan Smelting & Refining Co., of Detroit.

Mr. CHARLES H. REPATH is at the Calumet & Hecla works at Lake Linden, Michigan, in a consulting capacity.

Dr. THEODORE W. RICHARDS, professor of chemistry at Harvard University, has been elected president of the American Academy of Arts and Sciences.

Dr. W. H. RODEBUSH has left the research laboratory of the U. S. Industrial Alcohol Co., South Baltimore, Maryland, to take a National Research Council Fellowship at the University of California, Berkeley, California.

Mr. A. A. SCHNEIDER, formerly with the Raw Materials Department of the Midvale Steel & Ordnance Co., and the Cambria Steel Co., has been appointed manager of the newly created Raw Materials Division of the American Steel Export Co.

Dr. F. W. SKIRROW, for the past four years assistant professor of chemistry at McGill University, has resigned this position to take up the duties of chief chemist to the Shawinigan Laboratories, Ltd., the newly founded research organization of the Shawinigan Water and Power Co., Shawinigan Falls, Quebec.

Mr. E. E. THUM, who has been stationed in Salt Lake City, Utah, since Jan. 1, 1918, as Western Editor of CHEMICAL & METALLURGICAL ENGINEERING, has been transferred to the main editorial office in New York City, and will act as Associate Editor. The new Western Editor is Mr. L. W. CHAPMAN, whose headquarters are in San Francisco.

Mr. C. H. WILDRIDGE has accepted a position with the Manitoba Steel Foundries at Selkirk, Manitoba. He was formerly with R. W. Hunt & Co., Montreal.

Current Market Reports

The Non-Ferrous Metal Market

Tuesday, Sept. 9.—No important fluctuations in market prices have taken place in the last two weeks, with the exception of zinc, which declined. Sellers are firm, volume of sales is not large, but European buyers are said to be making preparations for important deals.

Aluminum:—Transactions are largely made on direct contract between producer and consumers. The open market is not active; 98-99 per cent ingots are quoted at 32-33c. per lb., remelt at 31-32c. Scrap casting, 21-24c.; sheet scrap, 22½-23c., and clippings, 24-27½c.

Antimony:—The market is easy; spot wholesale is quoted at 8¾c. and futures at 8c. lb. Small job lots, 9c. lb.

Copper:—Some resale copper is being sold at 22½c, but the market price is 23½c. lb. for September and 24c. for October.

Copper sheets, hot-rolled	lb.	33.50 — .....
Copper sheets, cold rolled	lb.	35.00 — .....
Copper bottoms	lb.	41.50 — .....
Copper rods	lb.	24.00 — .....
Copper wire	lb.	26.00 — .....
High brass wire and sheets	lb.	27.75 — .....
High brass rods	lb.	26.75 — .....
Low brass wire and sheets	lb.	30.50 — .....
Low brass rods	lb.	31.25 — .....
Brazed brass tubing	lb.	39.00 — .....
Brazed bronze tubing	lb.	44.25 — .....
Seamless copper tubing	lb.	37.50 — .....
Seamless bronze tubing	lb.	40.00 — .....
Seamless brass tubing	lb.	36.00 — .....
Scrap, heavy machinery comp		17½ — 18½
Scrap, heavy and wire		17½ — 18½
Scrap, light and bottoms		15½ — 16½
Scrap, heavy, cut and crucible		19 — 20
Scrap brass, heavy		10½ — 11½
Scrap brass, casting		12 — 13
Scrap brass, light		9½ — 10½
Scrap, No. 1 clean brass turnings		10½ — 11½
Scrap, No. 1 comp. turnings		16 — 16½

Lead:—The lead market is stronger, spot New York being 5.9-6c. lb. and East St. Louis 5.75c. lb. Cut lead sheets are bringing 9c.

Tin:—The tin market has not gathered the expected momentum downward. Straits spots are quoted at 56½c. and 99 per cent electrolytic, 55⅝c. lb.

Zinc:—Spot zinc has declined, but futures are quoted on a rising rate. Spot New York, 7.65c. lb.; October, 7.7c. East St. Louis spot, 7.3c.; October, 7.35c.

OTHER METALS

Bismuth	lb.	$2.95 —	.....
Cadmium	lb.	1.50 —	1.75
Cobalt	lb.	2.50 —	3.50
Magnesium	lb.	1.75 —	2.10
Mercury	75 lb.	100.00 —	.....
Nickel	lb.	.41 —	.45
Iridium	oz.	175.00 —	.....
Palladium	oz.	115.00 —	120.00
Platinum	oz.	105.00 —	110.00
Silver	oz.	1.125—	.....

The Iron and Steel Market

At this writing it is uncertain whether there will be anything approaching a general strike in the iron and steel industry. The "strike committee" of the unions affiliated with the American Federation of Labor has pursued curious tactics, all suggestive that it has had doubts whether it could produce a strike by calling one and that its best chance to accomplish anything in the direction of establishing conference relations with the iron and steel manufacturers was to play the strike threat to the utmost. Strikes, being a species of mob psychology, are not welcome in the realm of prediction.

Production of steel ingots in August was at the rate of about 39,100,000 tons a year, or a 10 per cent better rate than that of July, and equal to about 80 per cent of capacity, conservatively estimated. One striking feature of the situation is that one could not count up anything like 20 per cent of idle capacity. Either the managements of various works intentionally refrained from pushing for tonnage, which is altogether improbable, or labor indifference prevented plant units from producing their normal tonnages.

Pig Iron Production 80 Per Cent of Capacity

From the efficiency standpoint pig iron makes a better showing, as the rate of production in the first half of September was approximately 80 per cent of estimated capacity, and with many furnaces idle, easily sufficient to count up 20 per cent, without including furnaces that are probably unfit. Conditions as to the unfitness of furnaces have changed, however, and it is improbable that there are furnaces equal to one-fourth the furnace capacity now active that can produce without loss in present conditions. A fundamental change has occurred whereby the labor cost per ton has increased much more at some furnaces than at others, due to high wage rates. Before the war there was more or less equalization, furnaces with low investment and high labor employment having some opportunity to compete with furnaces having low labor employment and heavy investment. In many quarters, therefore, there are predictions that with broader demand pig iron prices must advance. That may easily occur. Relative to finished steel products pig iron prices are perhaps too low. It is a statistical fact that finished steel prices stand at a much larger advance, in percentage, over pre-war averages than is the case with pig iron prices.

Deflation in Values Probable

Even steel prices are not as high, compared with pre-war averages, as are commodities in general. It is far from certain, moreover, that a general deflation in values is in prospect for the near future. Although European countries have very high exchange rates upon the United States, our foreign commerce is so aligned as to tend to produce or support inflation in this country, our merchandise trade balance being heavily in our favor, although whether this common expression to represent an excess of exports is really appropriate may be questioned. It is not certain that a large excess of exports at this time is really favorable to our economic situation.

For several weeks the steel mills have been rather indisposed to accept orders from other than regular customers. There are exceptions, but this has been the common attitude. On account of the disposition to refuse orders except from regular customers, the demand that has existed has appeared quite insistent and seems to be of larger volume than is really the case. As a matter of fact jobbers and manufacturing consumers are fairly well covered by contract to the end of the year.

Construction work involving the employment of steel shows a distinctly lagging tendency. New projects are not being undertaken at this time in expected volume. Investors evince a decided tendency to hesitate in the matter of engaging in large undertakings, and the common view is that the hesitancy is due to uncertainties as to the labor cost of construction work involving a long period for its completion, as well as uncertainty as to the time when the work would be completed and would begin to yield returns. For several months following the armistice the common appraisal was that investors would not take hold until the cost of construction material should come down. That is hardly the theory now, since it is generally admitted that there will be no large declines in the near future, but labor costs are on an average quite as important as material costs.

In view of the employment of steel in construction work being well below the normal for active times, and in view of the fact that scarcely any steel is passing to the railroads, the employment of the steel industry, running as it is at about 80 per cent of capacity, is remarkably large. Exports are absorbing only about 20 per cent of the current output, so that the current everyday consumption of steel in domestic trade is really very large.

The Chemical Market

New York, September 10, 1919.

The past two weeks have brought forth a new interest in heavy chemicals in the nature of price inquiries by consumers looking to the fall buying of supplies, with an equally pressing inquiry for deliveries over 1920. Following these inquiries fair sized contracts have been signed covering delivery during the coming year. But this tendency to contract is not confined to heavy chemicals alone. An appreciable volume of business on the leading coal tar intermediates has been contracted for next year. Slashing of prices on many of the vegetable oils, heavy buying of crude rubber by leading tire manufacturers, as well as by dealers last week, with a very dull market on both waxes and naval stores sum up the latest developments.

Heavy Chemicals

Deliveries on existing contracts make up the bulk of present activity in industrial chemicals. Manufacturers are so busy that ten days is the best delivery possible on new orders. Stocks in second hands, too, appear to be less plentiful.

All manufacturers are behind in the production of *sodium bichromate* and do not expect to be caught up until January 1. Their quotations are 15-16c. per lb., sales being made only to old customers. At the last writing, when demand was less active, 14c was the minimum offered by dealers, but at present they are quoting firmly at 14½-15c. The demand is not only foreign, but emanates from the tanners as well.

Bleaching powder (calcium hypochlorite) is one of the products for which contracts have been signed, Buenos Aires being a heavy buyer in the foreign field. The price has been raised to $2.25 per cwt. by some dealers, others announcing no change.

Caustic soda (sodium hydroxide) is active with England offering some lively competition. The price on contract for 1920 is given as $2.82 per cwt., for 60 per cent, f.o.b. works.

Among the chemicals on which the shortage is especially felt are *sodium sulphide, muriatic (hydrochloric) acid, Glauber's salt, soda ash, potassium prussiate, yellow, and glacial acetic acid.* But despite this condition there have been no alterations in price. One large producer who is unable to accept new business in muriatic acid, asserts that if he were in a position to spare any of his output it could be readily marketed at $1.75 per cwt. in tank cars, as compared with the previous maximum figure of $1.50. The scarcity of *potassium, prussiate, yellow,* is readily accounted for by the fact that manufacturers, finding its production unremunerative, have ceased to make it until the price attains a stable basis.

During the past week *formaldehyde* was moved up by several dealers to 22½c. per lb. from 19-21c. Probably the lowest figure at which it can be bought is 20½c. Back of the advance is the paucity of stocks and the sold-up condi-

tion of manufacturers as well as the firm position of wood alcohol.

Ostensibly with the object of reducing competition in second hands, domestic manufacturers of *tartaric acid* have announced a reduction of approximately 7c per lb., thus establishing the market for crystals and powdered at 79½c. This sharp cut was primarily made possible because of the improvement in the raw material situation.

On Sept. 2 a new schedule of prices for refined sulphur was announced, according to which sulphur flowers is quoted at $3.10 per cwt. in carlots and sulphur, roll, at $2.95.

Aluminum sulphate and *salt cake* (*sodium sulphate*) conclude the list of particularly active chemicals. With paper mills running to capacity, they are pressing for shipments of the former. Salt cake is well sold up for domestic use, while inquiries are coming from Norway, Sweden, Finland and Canada. But owing to the lack of an international medium of exchange between Scandinavia and United States, England is in a better position to handle this demand, while American producers must underquote England to place orders in Canada.

Oils

The present dullness and sharp cut in prices of vegetable oils can be attributed to three facts: the Government movement to reduce prices, the adverse exchange situation and the failure of European demand. The stoppage of buying from Europe is, of course, almost entirely due to exchange, for fats and oils are needed there as urgently as ever.

Dealers believe that the present condition is merely transient and that prices will begin to creep back, especially when domestic consumers realize that stocks are not large. The majority of oils are selling on an average of at least a cent under last market quotations. The weak condition of the local linseed oil market is evinced by a drop of 10c on September oil, to $2.12 per gal. for raw oil in carlots. Some, however, hold to the old level of $2.22 for spot delivery. October-November delivery is held at $1.98 per gal., December-January at $1.93.

Fish oils are sharing in the downward trend, winter pressed Menhaden now being quoted at $1.32 per gal., a decrease of 3c.

Coal Tar Products

Reflecting the recent boom and heavy trading in coal tar intermediates, as well as the augmenting price of raw materials, several price advances are announced. Aniline oil still retains the spotlight of interest. If it was scarce two weeks ago its present status can easily be inferred from the fact that the output of a leading producer is sold from thirty to forty-five days in advance. Whereas a fortnight ago it could be bought at 26c. per lb. little is now obtainable at 30c., manufacturers' prices ranging anywhere from 30-33c.

Along with aniline oil, aniline salt is a scarce item. Although at this writing no advance in price has been made, if demand continues with the present impetus, an increase is likely.

Both salol and salicylic acid have increased in market value by 5c per lb. which fixes the inside figure of the former at 85c and that of the latter at 45c.

Along with the advances in prices is not to be overlooked the encouraging tendency to contract. As a result a fair volume of future business has been closed for aniline oil, beta-naphthol and dimethylaniline, which products, excepting beta-naphthol, are being bought in quantities by Japan and Mexico.

Varying from the general tendency in the coal tar field, competition has brought benzoic acid to 90c per lb. from the previous quotation of $1.00-$1.10.

Now that the sale of Government phenol has been settled, with the Monsanto Chemical Co. acting as the sole selling agent, stocks are being offered at 12-15c per lb. works according to quantity and quality, and subject to certain restrictions. As yet sales cannot be made for export although there is a good demand.

Crude Rubber

Initiating a departure from the continued tranquility in the crude rubber market, plantation grades developed unusual strength last week, all grades being advanced approximately 5c. per lb. Some large orders for October-December and January-June delivery were placed by leading tire manufacturers, who have been holding out of the market. Dealers kept up their end of the activity by purchasing heavily.

Although buying has slowed down perceptibly during the present week, firm foreign markets taken in conjunction with the fact that futures are still quoted above spot (a reversal of normal conditions) presage a firm market with higher prices.

Naval Stores

The demand for pine oil, which is at present said to be larger than can be supplied, is not to be taken as an indication of the state of affairs among naval stores. Last week when some activity was in evidence spirits of turpentine suddenly jumped to $1.91 per gal. It has rapidly declined until the present finds it at $1.63. This instability of turpentine has led to the substitution, wherever possible, of the lower priced pine oil. Pine oil, steam distilled, holds at $1.05 per gal.

Chicago, September 10, 1919.

Settled prices and a rather quiet market are the rule in all lines in the Chicago district. Buying continues sufficiently active to sustain prices at existing levels, which in many instances seem high, but is apparently confined to current needs, no one caring to take a chance and lay in surplus stock at prevailing costs. Export business remains negligible, and will probably remain so while foreign exchange rates are so unfavorable.

Heavy Chemicals: Quotations made months ago, viz: Caustic soda, solid, 3½c. granulated, 4c.; soda ash, 2c., and bleaching powder (calcium hypochlorite), 2c., still hold good with demand steady and supply ample. Short supplies keep prices of red and yellow potassium prussiate and sodium bichromate up to the high points reached six weeks ago. With the exception of nitric, the acids show no change. 60 deg and 66 deg. sulphuric acid are quoted at $12 and $18 respectively, with fair demand for the lower grade. 18 deg. muriatic stands at $22, but nitric, under weak demand, has fallen off to 9c. for spot delivery. Some export business has been handled on methyl alcohol but quotation stands at about $1.25.

Coal Tar Products: The items in this line show undoubted strength. Toluol and benzol at 26c. and 25c. respectively are firmly held and aniline oil in drums advanced 3c. last week, now being quoted at 29c., with spot stocks exhausted and none offered for future delivery before November. Aniline salts have shared in this advance and now are 35c. for immediate delivery. Heavy demand for these commodities from local industries has created a shortage which it will apparently take some time to overcome.

Vegetable Oils: Over-inflation of prices some weeks is evidenced by the continued slump at present. Even linseed oil, under good and wide-spread demand, has declined five cents, $2.13 being asked for large lots, $2.37 for less than five barrels. Current quotations are: corn oil, 21c.; soya bean oil, 17c.; cocoanut oil, 21c., and cottonseedp oil, 30c.

Flotation Oils, Naval Stores: A slight reaction has occurred, all grades of rosin being, at present, off about 50c. compared with thirty days ago. Today's quotation on W. W. grade is $24 and on F grade, $21. Turpentine is obtainable in limited quantities at $1.73, having recently had a decline of 15c. followed by a quick recovery. Prices on distilled pine oil and pine tar oil show but one or two cents decline.

That pine tar products should have weakened at all is rather surprising, but is accounted for by the fact that many small producers of crude, tempted by prevailing high prices, have placed their entire stocks on the market. If this explanation is correct, some further slight decreases may be anticipated, but are almost certain to be followed by a market as strong, or even stronger than that of a few weeks ago. It is a fact that production has not equaled the season's demand, high prices being, therefore, inevitable.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET, SEPT. 10, 1919

		Carlots	Less Carlots
Acetic anhydride	lb.	.....	$0.55 – $0.60
Acetone	lb.	$0.13½ – $0.14	.15 – .15½
Acid, acetic, 28 per cent.	cwt.	2.50 – 3.00	3.00 – 3.25
Acetic, 56 per cent.	cwt.	5.00 – 5.50	6.00 – 6.50
Acetic, glacial, 99½ per cent, carboys	cwt.	12.00 – 12.50	12.90 – 13.50
Boric, crystals	lb.	.13 – .13½	.13½ – .14
Boric, powder	lb.	.13 – .13½	.13½ – .14
Hydrochloric, (muriatic) tech. 20 deg.	cwt.	1.50 – 1.75	2.00 – 2.50
Hydrofluoric, 52 deg.	lb.	.10 –	.11 – .....
Lactic, 44 per cent. tech.	lb.	.11 – .14	.12 – .16
Lactic, 22 per cent. tech.	lb.	.05 – .06	.05½ – .07
Molybdic, C. P.	lb.	..... –	4.50 – 5.50
Nitric, 40 deg.	lb.	.06 – .06½	.07 – .08½
Nitric, 42 deg.	lb.	.07 – .07½	.08 – .....
Oxalic, crystals	lb.	.23 – .25	.25 – .30
Phosphoric, Ortho, 50 per cent. solution	lb.	.09 –	.10 – .14
Picric	lb.	.30 – .40	.50 – .....
Pyrogallic, resublimed	lb.	..... –	2.30 – 2.45
Sulphuric, 60 deg., tank cars	ton	12.00 – 16.00	..... – .....
Sulphuric, 60 deg., drums	ton	17.00 –	22.00 – .....
Sulphuric, 60 deg., carboys	ton	20.00 –	25.00 – .....
Sulphuric, 66 deg., tank cars	ton	17.00 – 18.00	22.00 – 23.00
Sulphuric, 66 deg., drums	ton	20.00 – 21.00	25.00 – 26.00
Sulphuric, 66 deg., carboys	ton	25.00 –	30.00 – 40.00
Sulphuric, fuming, 20 per cent. (oleum) tank cars	ton	20.00 –	27.00 – .....
Sulphuric, fuming, 20 per cent. (oleum) drums	ton	25.00 –	32.00 – .....
Sulphuric, fuming, 20 per cent. (oleum) carboys	ton	30.00 –	35.00 – .....
Tannic, U. S. P.	lb.	..... –	1.30 – 1.45
Tannic (tech.)	lb.	..... –	.42 – .55
Tartaric, crystals	lb.	..... –	.84 – .86
Tungstic, per lb. of WO	lb.	..... –	1.20 – 1.40
Alcohol, Ethyl	gal.	4.75 –	4.90 – .....
Alcohol, Methyl	gal.	1.30 –	1.33 – 1.38
Alcohol, denatured, 188 proof	gal.	.52 –	.54 – .55
Alcohol, denatured, 190 proof	gal.	.46 – .48	.50 – .51
Alum, ammonia lump	lb.	.03½ – .04½	.04½ – .04½
Alum, potash lump	lb.	.08 – .08½	.09 – .09½
Alum, chrome lump	lb.	.15 – .16	.18 – .20
Aluminum sulphate, commercial	lb.	.01½ – .02	.02½ – .02½
Aluminum sulphate, iron free	lb.	.02½ – .03	.03½ – .03½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.06½ –	.07 – .08
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	..... –	.30 – .35
Ammonium carbonate, powder	lb.	.13 – .13½	.14 – .14½
Ammonium chloride, granular (white salammoniac)	lb.	.12½ – .13	.13½ – .14
Ammonium chloride, granular (gray salammoniac)	lb.	.12 – .12½	.13 – .13½
Ammonium nitrate	lb.	.10 –	.11 – .12
Ammonium sulphate	lb.	.05 –	.06 – .....
Amyl acetate	gal.	..... –	3.75 – 4.00
Arsenic, oxide, lumps (white arsenic)	lb.	..... –	.09 – .09½
Arsenic, sulphide, powdered (red arsenic)	lb.	..... –	..... – .....
Barium chloride	ton	75.00 – 80.00	85.00 – 87.50
Barium dioxide (peroxide)	lb.	.22 –	.24 – .....
Barium nitrate	lb.	.10 – .10½	.11 – .12
Barium sulphate (precip.) (blanc fixe)	lb.	.02½ – .03	.03½ – .04
Bleaching powder (see calcium hypochlorite)		..... –	..... – .....
Blue Vitriol (see copper sulphate)		..... –	..... – .....
Borax (see sodium borate)		..... –	..... – .....
Brimatone (see sulphur, roll)		..... –	..... – .....
Bromine	lb.	..... –	.65 – .75
Calcium acetate	cwt.	2.00 – 2.05	2.10 – .....
Calcium carbide	lb.	..... –	.04 – .05
Calcium chloride, fused, lump	ton	19.00 – 25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½ – .01½	.02 – .02½
Calcium hypochlorite (bleaching powder)	cwt.	1.75 – 1.90	2.00 – 2.50
Calcium peroxide	lb.	..... –	1.50 – 1.70
Calcium phosphate, monobasic	lb.	..... –	.75 – .....
Calcium sulphate, precipitated	lb.	..... –	.09 – .09½
Carbon bisulphide	lb.	.05½ –	.06 – .....
Carbon tetrachloride, drums	lb.	.10 – .11	.12 – .14
Carbonyl chloride (phosgene)	lb.	..... –	.75 – .....
Caustic potash (see potassium hydroxide)		..... –	..... – .....
Caustic soda (see sodium hydroxide)		..... –	..... – .....
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.05 – .05½	.08 – .....
Cobalt oxide	lb.	..... –	1.60 – 1.65
Copperas (see iron sulphate)		..... –	..... – .....
Copper carbonate, green precipitate	lb.	..... –	.28 – .31
Copper cyanide	lb.	..... –	.65 – .70
Copper sulphate, crystals	lb.	.08½ – .08¾	.09 – .09½
Cream of tartar (see potassium bitartrate)		..... –	..... – .....
Epsom salt (see magnesium sulphate)		..... –	..... – .....
Formaldehyde, 40 per cent.	lb.	..... –	.20 – .22½
Glauber's salt (see sodium sulphate)		..... –	..... – .....
Glycerine	lb.	..... –	.19 – .21
Iodine, resublimed	lb.	..... –	4.50 – .....
Iron oxide, red	lb.	..... –	.03 – .20
Iron sulphate, (copperas)	cwt.	1.00 –	1.20 – 1.50
Lead acetate, normal	lb.	..... –	.12½ – 14½
Lead arsenate (paste)	lb.	..... –	.13 – .17
Lead nitrate, crystals	lb.	..... –	.85 – .86½
Litharge	lb.	..... –	.09½ – .10½
Lithium Carbonate	lb.	..... –	1.50 – .....
Magnesium carbonate, technical	lb.	..... –	.13 – .14½
Magnesium sulphate, U. S. P.	100 lb.	2.00 – 2.63	2.75 – 3.00
Magnesium sulphate, commercial	100 lb.	1.75 –	2.00 – 2.50
Nickel salt, double	lb.	.14 –	.15 – .....
Nickel salt, single	lb.	.12 –	.15 – .16
Phosgene (see carbonyl chloride)		..... –	..... – .....
Phosphorus, red	lb.	..... –	.60 – .70
Phosphorus, yellow	lb.	..... –	.35 – .37
Potassium bichromate	lb.	.25 – .28	..... – .....
Potassium bitartrate (cream of Tartar)	lb.	..... –	.55 – .60
Potassium bromide, granular	lb.	..... –	.49 – .50
Potassium carbonate, U. S. P.	lb.	.60 –	.65 – .70
Potassium carbonate, crude	lb.	.17 –	.20 – .....
Potassium chlorate, crystals	lb.	.20 – .24	.25 – .30
Potassium cyanide, 98-99 per cent.	lb.	nominal	
Potassium hydroxide (caustic potash)	lb.	.30 – .32	.35 – .40
Potassium iodide	lb.	..... –	3.55 – 3.60
Potassium nitrate	lb.	.19 –	.21 – .....
Potassium permanganate	lb.	..... –	.55 – .65
Potassium prussiate, red	lb.	..... –	.90 – 1.10
Potassium prussiate, yellow	lb.	..... –	.50 – .60
Potassium sulphate	ton	225.00 –	..... – .....
Rochelle salts (see sodium potas, tartrate)		..... –	..... – .....
Salammoniac (see ammonium chloride)		..... –	..... – .....
Sal soda (see sodium carbonate)		..... –	..... – .....
Salt cake (sodium sulphate)	ton	17.00 – 18.00	..... – .....
Silver cyanide	oz.	..... –	1.19 – .....
Silver nitrate	oz.	..... –	.70½ – .....
Soda ash, light	100 lb.	1.85 – 1.90	2.00 – .....
Soda ash, dense	100 lb.	2.25 –	2.50 – .....
Sodium acetate	lb.	.05½ – .06½	.07 – .08
Sodium bicarbonate	100 lb.	2.35 –	2.75 – 3.00
Sodium bichromate	lb.	.14½ –	.15 – .16
Sodium bisulphate (nitre cake)	ton	3.00 – 8.00	10.00 – .....
Sodium bisulphite	cwt.	1.80 – 1.90	2.00 – 2.10
Sodium borate (borax)	lb.	.07½ –	.08 – .08½
Sodium carbonate (sal soda)	100 lb.	1.35 – 1.50	1.50 – 1.75
Sodium chlorate	lb.	.15 –	.16 – .18½
Sodium cyanide	lb.	.30 –	.31 – .34
Sodium fluoride	lb.	.13 –	.14 – .15
Sodium hydroxide (caustic soda)	100 lb.	2.75 –	2.90 – 3.50
Sodium molybdate	lb.	2.50 –	3.25 – .....
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4.00
Sodium nitrite	lb.	.09½ – .10	.10½ – .13
Sodium peroxide, powdered	lb.	..... –	.30 – .32
Sodium phosphate, dibasic	lb.	.03½ – .04½	.04 – .05
Sodium potassium tartrate (Rochelle salts)	lb.	..... –	.43 – .45½
Sodium prussiate, yellow	lb.	.17½ – .18½	.19 – .20
Sodium silicate, solution (40 deg.)	lb.	.01½ – .02	.02 – .02½
Sodium silicate, solution (60 deg.)	lb.	.02½ – .03	.03½ – .04½
Sodium sulphate, crystals (Glauber's salts)	cwt.	1.05 – 1.35	1.50 – 2.00
Sodium sulphide, crystal, 60-62 per cent. (conc)	lb.	..... –	.05 – .06
Sodium sulphite, crystals	lb.	.03½ –	.04 – .....
Strontium nitrate, crystals	lb.	.25 –	..... – .28
Sulphur chloride	lb.	.05½ –	..... – .06
Sulphur, crude	ton	22.00 –	..... – .....
Sulphur dioxide, liquid, cylinders	lb.	..... –	.10 – .12
Sulphur (sublimed), flowers	100 lb.	3.10 –	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	2.95 –	3.15 – 3.40
Tin bichloride (stannous)	lb.	.44 –	.46 – .50
Tin oxide	lb.	..... –	.60 – .....
Zinc carbonate, precipitate	lb.	..... –	.20 – .....
Zinc chloride, gran.	lb.	.12½ –	.13½ – .14
Zinc cyanide	lb.	.49 –	.50 – .....
Zinc dust	lb.	.09 – .11	.11 – .14
Zinc oxide, dry American	lb.	..... –	.10 – .13
Zinc sulphate	lb.	.03½ – .03¾	.04 – .04½

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00 —	$1.10
Alpha naphthol, refined	lb.	1.40 —	1.50
Alpha naphthylamine	lb.	.35 —	.50
Aniline oil, drums extra	lb.	.28½ —	.33
Aniline salts	lb.	.28 —	.33
Anthracine, 80% in drums (100 lb.)	lb.	.90 —	1.00
Benzaldehyde (f.f.c.)	lb.	1.00 —	1.15
Benzidine, base	lb.	1.00 —	1.25
Benzidine, sulphate	lb.	1.00 —	1.15
Benzoic acid, U. S. P.	lb.	.90 —	1.10
Benzoate of soda, U. S. P.	lb.	.85 —	1.10
Benzol, pure, water-white, in drums (100 lb.)	gal.	.25 —	.29
Benzol, 90%, in drums (100 lb.)	gal.	.24 —	.28
Benzyl chloride, 95-97%, refined	lb.	.35 —	.40
Benzyl chloride, tech.	lb.	.25 —	.35
Beta naphthol benzoate	lb.	3.75 —	4.50
Beta naphthol, sublimed	lb.	.75 —	.80
Beta naphthol, tech.	lb.	.45 —	.55
Beta naphthylamine, sublimed	lb.	2.25 —	2.35
Cresol, U. S. P., in drums (100 lb.)	lb.	.18 —	.....
Ortho-cresol, in drums (100 lb.)	lb.	.23 —	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	.85 —	.90
Cresylic acid, 95-97%, dark, in drums	gal.	.80 —	.85
Cresylic acid, 50%, first quality, drums	gal.	.60 —	.....
Dichlorbenzol	lb.	.07 —	.10
Diethylaniline	lb.	1.40 —	2.25
Dimethylaniline	lb.	.55 —	.60
Dinitrobenzol	lb.	.26 —	.37
Dinitroclorbenzol	lb.	.25 —	.30
Dinitronaphthaline	lb.	.45 —	.55
Dinitrophenol	lb.	.33 —	.36
Dinitrotoluol	lb.	.38 —	.45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 —	.65
Diphenylamine	lb.	.58 —	.75
H-acid	lb.	1.60 —	1.75
Metaphenylenediamine	lb.	1.15 —	1.80
Monochlorbenzol	lb.	.12 —	.15
Monoethylaniline	lb.	1.50 —	1.75
Naphthaline crushed, in bbls. (250 lb.)	lb.	.06 —	.08
Naphthaline, flake	lb.	.06½ —	.07½
Naphthaline, balls	lb.	.08½ —	.10
Naphthionic acid, crude	lb.	.75 —	1.25
Nitrobenzol	lb.	.14 —	.19
Nitro-naphthaline	lb.	.35 —	.45
Nitro-toluol	lb.	.17 —	.20
Ortho-amidophenol	lb.	4.25 —	.....
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-nitro-phenol	lb.	.90 —	1.25
Ortho-nitro-toluol	lb.	.27 —	.40
Ortho-toluidine	lb.	.30 —	.45
Para-amidophenol, base	lb.	2.60 —	3.50
Para-amidophenol, HCl	lb.	2.75 —	3.25
Para-dichlor-benzol	lb.	.15 —	.18
Paranitraniline	lb.	.95 —	1.10
Para-nitro-toluol	lb.	1.35 —	1.50
Paraphenylenediamine	lb.	2.50 —	4.00
Paratoluidine	lb.	1.50 —	2.50
Phthalic anhydride	lb.	1.75 —	2.15
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	.12 —	.15
Pyridin	gal.	2.50 —	.....
Resorcin, technical	lb.	3.50 —	3.75
Resorcin, pure	lb.	6.50 —	6.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.35 —	.40
Salicylic acid, U. S. P.	lb.	.45 —	.48
Salol	lb.	.85 —	.95
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.20 —	.27
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.18 —	.24
Sulphanilic acid, crude	lb.	.25 —	.30

Tolidine	lb.	$1.70	—	$2.50
Toluidine, mixed	lb.	.45	—	.55
Toluol, in tank cars	gal.	.26	—	.....
Toluol, in drums	gal.	.30	—	.....
Xylidine, drums, 100 gal.	lb.	.44	—	.50
Xylol, pure, in drums	gal.	.37	—	.45
Xylol, pure, in tank cars	gal.	.35	—	.....
Xylol, commercial, in drums, 100 gal.	gal.	.23	—	.27
Xylol, commercial, in tank cars	gal.	.22	—	.....

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow	lb.	$0.41	—	$0.45
Beeswax, refined, yellow	lb.	.48	—	.49
Beeswax, white pure	lb.	.65	—	.68
Carnauba, No. 1	lb.	.86	—	.88
Carnauba, No. 2, regular	lb.	.65	—	.80
Carnauba, No. 3, North Country	lb.	.55	—	.56
Japan	lb.	.18½	—	.20
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.06	—	.....
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.06	—	.06½
Paraffine waxes, refined, 118-120 m.p.	lb.	.07½	—	.08
Paraffine waxes, refined, 128-130 m.p.	lb.	.08½	—	.09
Paraffine waxes, refined, 133-135 m.p.	lb.	.10½	—	.11
Paraffine waxes, refined, 135-137 m.p.	lb.	.12	—	.13
Stearic acid, single pressed	lb.	.23	—	.26
Stearic acid, double pressed	lb.	.27	—	.28
Stearic acid, triple pressed	lb.	.30	—	.33

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.05
Pine oil, pure, dest. dist.	gal.	.85
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.45
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.33
Pine tar oil, double ref., sp.gr. 0.965-0.990	gal.	.65
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.34
Turpentine, crude, sp. gr., 0.900-0.970	gal.	.85
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.30
Pinewood creosote, ref.	gal.	.48

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl.	280 lb.	$16.80	—	$18.25
Rosin E-I	280 lb.	18.50	—	20.75
Rosin K-N	280 lb.	22.00	—	24.00
Rosin W. G.-W. W.	280 lb.	24.50	—	25.25
Wood rosin, bbl.	280 lb.	17.00	—	18.25
Spirits of turpentine	gal.	1.67	—	1.73
Wood turpentine, steam dist.	gal.	1.63	—	.....
Wood turpentine, dest. dist.	gal.	1.50	—	.....
Pine tar pitch, bbl.	200 lb.	8.25	—	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	12.75	—	13.50
Retort tar, bbl.	280 lb.	13.75	—	14.50
Rosin oil, first run	gal.	.86	—	.91
Rosin oil, second run	gal.	.88	—	.93
Rosin oil, third run	gal.	.95	—	1.07
Rosin oil, fourth run	gal.	1.05	—	1.10

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½		
70-72 deg., steel bbls. (85 lb.)	gal.	.31½		
68-70 deg., steel bbls. (85 lb.)	gal.	.30½		
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23½		

Crude Rubber

Para—Upriver fine	lb.	$0.55½	—	$0.56
Upriver coarse	lb.	.32½	—	.33
Upriver caucho ball	lb.	.32½	—	.....
Plantation—First latex crepe	lb.	.50	—	.50½
Ribbed smoked sheets	lb.	.49	—	.....
Brown crepe, thin, clean	lb.	.41½	—	.45
Amber crepe No. 1	lb.	.43½	—	.47

Oils

VEGETABLE

Unless otherwise noted, the following prices are f.o.b., New York.

Castor oil, No. 3, in bbls.	lb.	$0.18½	—	$0.19
Castor oil, AA, in bbls.	lb.	.21	—	.22
China wood oil, in bbls.	lb.	.21	—	.24
Cocoanut oil, Ceylon grade, in bbls.	lb.	.18	—	.18½
Cocoanut oil, Cochin grade, in bbls.	lb.	.19½	—	.21
Corn oil, crude, in bbls.	lb.	.20	—	.23
Cottonseed oil, crude (f.o.b. mill)	lb.	.18	—	.20
Cottonseed oil, summer yellow	lb.	.25	—	.27
Cottonseed oil, winter yellow	lb.	.26½	—	.28
Linseed oil, raw, car lots	gal.	2.05	—	2.22
Linseed oil, raw, tank cars	gal.	2.10	—	2.19
Linseed oil, boiled, car lots	gal.	2.07	—	2.20
Olive oil, commercial	gal.	2.30	—	2.50
Palm, Lagos	lb.	.17	—	.18
Palm, bright red	lb.	.16½	—	.17
Palm, Niger	lb.	.16	—	.17
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.22	—	.24
Peanut oil, refined, in bbls.	lb.	.27½	—	.28
Rapeseed oil, refined in bbls.	gal.	1.50	—	1.60
Rapeseed oil, blown, in bbls.	gal.	1.57	—	1.70
Soya bean oil (Manchurian), in bbls., N. Y.	lb.	.18	—	.18½
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.14½	—	.15

FISH

Winter pressed Menhaden	gal.	$1.28	—	$1.32
Yellow bleached Menhaden	gal.	1.30	—	1.35
White bleached Menhaden	gal.	1.32	—	1.36
Blown Menhaden	gal.	1.38	—	.....

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$25.00	—	$36.00
Barytes, off color	ton	20.00	—	25.00
Blanc fixe, dry	lb.	.03½	—	.04½
Blanc fixe, pulp	ton	35.00	—	47.50
Casein	lb.	.16	—	.18
Chalk, English, extra light	lb.	.05	—	.07
Chalk, English, light	lb.	.04½	—	.06
Chalk, English, dense	lb.	$ .04	—	$ .05
China clay (Kaolin), imported, lump	ton	25.00	—	35.00
China clay (Kaolin), imported, powdered	ton	30.00	—	60.00
China clay (Kaolin), domestic, lump	ton	10.00	—	20.00
China clay (Kaolin), domestic, powdered	ton	25.00	—	40.00
Feldspar	ton	11.50	—	16.00
Fluorspar, acid grade, lump, f.o.b. mines	net ton	$30.00	—	$35.00
Fluorspar, acid grade, ground, f.o.b. mines	net ton	35.00	—	45.00
Fuller's earth, domestic, powdered	ton	30.00	—	40.00
Fuller's earth, imported, powdered	ton	.....	—	.....
Pumice stone, imported	lb.	.03	—	.06
Pumice stone, domestic	lb.	.02½	—	.....
Shellac, TN	lb.	1.20	—	.....
Shellac, D. C.	lb.	.....	—	.....
Shellac, V. S. O.	lb.	.....	—	.....
Shellac, Diamond I.	lb.	.....	—	.....
Shellac, orange, fine	lb.	.....	—	.....
Shellac, orange, superfine	lb.	1.35	—	.....
Shellac, A.C. garnet	lb.	.....	—	.....
Shellac, bleached, bone dry	lb.	1.40	—	.....
Shellac, bleached, fresh ground	lb.	1.10	—	.....
Soapstone	ton	15.00	—	25.00
Talc, domestic	ton	16.00	—	60.00
Talc, imported	ton	55.00	—	60.00

Refractories

Following prices are f.o.b. works:

Chrome brick	net ton	80-90 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	net ton	35-45 at Clearfield, Penn.
Clay brick, 2nd quality	net ton	30-35 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-90 at Chester, Penn.
Silica brick	net ton	41-45 at Mt. Union, Penn.

Ferro-alloys

All prices f.o.b. works.

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00	—	$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.30	—	.40
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon	lb.	.70	—	.....
Ferro-manganese, 70-80% Mn	gross ton	105.00	—	115.00
Spiegeleisen, 16-20% Mn	gross ton	35.00	—	36.00
Ferro-molydenum, per lb. of Mo	lb.	2.50	—	3.00
Ferro-silicon, 50%	gross ton	85.00	—	95.00
Ferro-silicon, 75%	gross ton	150.00	—	175.00
Ferro-silicon, 10-15%	gross ton	45.00	—	60.00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb.	1.25	—	1.40
Ferro-uranium, 35-50%, of U	lb.	7.00	—	.....
Ferro-vanadium, 30-40% per lb. of contained V.	lb.	5.50	—	7.00

Ores and Semi-finished Products

Chrome ore, 35-40%, Cr_2O_3	unit	$0.60	—	$0.80
Chrome ore, 48% and over	unit	.90	—	1.00
Coke, foundry, f.o.b. ovens	net ton	5.50	—	6.00
Coke, furnace, f.o.b. ovens	net ton	4.00	—	5.00
Petroleum coke, refinery, Atlantic seaboard	net ton	12.00	—	.....
Fluorspar, gravel, f.o.b. mines	net ton	20.00	—	25.00
Manganese ore, 45% Mn and over	unit	.50	—	.75
Manganese ore, chemical (MnO_2)	gross ton	60.00	—	70.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75	—	.85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	9.00	—	15.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	7.50	—	10.00
Uranium oxide, 96%	lb.	.....	—	.....
Vanadium pentoxide, 99%	lb.	6.00	—	.....
Pyrites, foreign, lump	unit	.13	—	.....
Pyrites, foreign, fine	unit	.13	—	.....
Pyrites, domestic, fine	unit	.14	—	.17½
Ilmenite, 52% TiO_2, f.o.b. N. Y.	net ton	40.00	—	.....
Rutile, 95% TiO_2, f.o.b. N. Y.	net ton	200.00	—	.....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75	—	3.00
Zircon, washed, iron free, f.o.b. N. Y.	net ton	135.00	—	.....
Monazite, per unit of ThO_2, f.o.b. N. Y.	unit	42.00	—	.....

Plant Materials and Supplies

In carload lots, New York, unless otherwise stated.

BUILDING MATERIALS

Portland cement, at dock, without bags	bbl.	$2.30
Lump lime, common, including container	300 bbl.	2.65
Common brick, at dock	M.	15.00
Yellow pine, 3x4 to 8x8, 20 ft. and under	M.	48.00
Yellow pine, 3x4 to 8x8, 20 ft. and under at Chicago	M.	55.00
Yellow pine, 3x4 to 8x8, 20 ft. and under at St. Louis	M.	43.00
Roofings, tar felt (14 lb. per 100 sq.ft.)	ton	60.00–70.00
Roofings, tar pitch (in 400-lb. bbl.) carlots	ton	21.00
Roofings, asphalt pitch carlots	ton	34.00
Roofings, asphalt felt carlots	ton	63.00
Roofings, slate-surfaced, per roll of 108 sq.ft. carlots		2.25
Roofings, slate-finished shingles, 100 sq.ft. carlots		6.00
Linseed oil, raw in barrels	gal.	2.15
Linseed oil, 5 gal. cans	gal.	2.30
Red lead, dry, 100 lb. keg	lb.	.13
Red lead, in oil, 100 lb. keg	lb.	.14½
Red lead, dry, 5 lb. cans	lb.	.15
Red lead, in oil, 5 lb. cans	lb.	.16½
White lead, dry and in oil, 100 lb. keg	lb.	.13
White lead, dry and in oil, 25 and 50 lb. kegs	lb.	.13½
White lead, dry and in oil, 5 lb. cans	lb.	.15

STRUCTURAL STEEL, MILL, PITTSBURGH

Beams and channels, 3 to 15-in.	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.66
Rivets, structural, ½-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ½-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.35
Sheets, No. 10 blue annealed	100 lb.	3.55
Sheets, No. 28 galvanized	100 lb.	5.70

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Arizona

CANON—The Kay Copper Co. (Yavapai Co.) is having plans prepared for the construction of a 100-ton concentration and flotation mill, 29 miles north of Peoria Station along the Santa Fe Ry.

MIAMI—The Miami Mining & Milling Co., Gila Co., recently purchased the old mill of the Arizona Butte Corp. and will improve same for its own use.

NOGALES—The Bachman Merrit Co., Santa Cruz Co., will erect a concentration mill to handle vanadium ores from Tres de Mayo property, 12 miles east of here.

PHOENIX—The Arizona Egyptian Cotton Co., 5th and Lincoln Sts. will erect a cottonseed oil refinery to have capacity of 10,000 gal. per day. H. B. Atha, manager.

STODDARD—The Copper Queen Gold Mining Co. has awarded the contract for the erection of a 100-ton flotation plant, to Kennard & Bierce, Higsworth St., Los Angeles, Cal. Estimated cost, $65,000.

TUCSON—The Paymaster-Silver Lead Co. will build a concentration mill, 100-ton capacity, at its mine at Olive Camp, 24 miles south of here. W. F. Hogan, superintendent.

WALKER — The Sheldon Mining Co., Yavapai Co., is planning extensive development work under the direction of Mark Bradley. A new compressor and other equipment will be installed.

California

GLENDALE—The city has engaged Olmsted & Gillelen, engineers, 1112 Hollingsworth Bldg., Los Angeles, to make surveys and submit reports and estimates for sewerage system and disposal works. Estimated cost, $400,000. J. C. Sherer, city clerk.

TORRANCE—The Western Glass Products Co., 707 Hibernian Bldg., Los Angeles, will build a group of buildings on a 10-acre site recently purchased here. A. LaCourse, Collingswood, N. J., engineer.

Connecticut

EAST BERLIN—The Connecticut Metal & Chemical Co., Grove Hill St., New Britain, has awarded the contract for the construction of a 1-story factory addition, to J. H. Grozier Co., 756 Main St., Hartford. Estimated cost, $25,000.

NEW HAVEN—The Atlantic Refining Co., 508 Turks Head Bldg., Providence, R. I., has awarded the contract for the construction of a 1-story, 26 x 26-ft. gas service station on Dixwell Ave. and Goffe St., to the Metzger & Fisher Co., Otis Bldg., Philadelphia, Pa. Estimated cost, $25,000.

WEST HAVEN—The Connecticut Fat Rendering & Fertilizer Co., Front Ave., has awarded the contract for the construction of a rendering plant, to Westcott & Mapes, Inc., 207 Orange St., New Haven. Estimated cost, $25,000.

Illinois

CHICAGO—H. G. Fischer & Co., 2341 Wakansia Ave., has awarded the contract for the construction of a 3-story, 60 x 110-ft. X-ray machine factory at 2339 Wakansia Ave., to R. L. Brockob, 5448 Flournoy St. Estimated cost, $70,000.

CHICAGO—G. C. Nimmoms, architect, 122 South Michigan Ave., is receiving bids for the construction of a 5-story, 125 x 127-ft. addition to wall paper factory of Sears, Roebuck & Co., Harvard and Homan Aves. Estimated cost, $225,000.

EAST WOODRIVER (Woodriver P. O.)—The International Shoe Co., 15th and Washington Aves., St. Louis, Mo., has awarded the contract for the construction of a 4-story, 130 x 600-ft. tannery, to the James Black Masonry & Contracting Co., Wright Bldg., St. Louis. Estimated cost, $800,000.

QUINCY—Frank H. Clark, of the National Oil & Refining Co., and others, plan to construct a new oil refinery, here. Estimated cost, $100,000.

Kansas

BELLE PLAIN—The city will soon award the contract for the construction of 6½ miles of sewers, disposal plant, etc. W. B. Rollins & Co., Railway Exchange Bldg., Kansas City, Mo., engineer.

Maryland

CURTIS BAY (Baltimore P. O.)—The U. S. Industrial Alcohol Co. has awarded the contract for the construction of a 2-story addition to its alcohol plant, here, to G. A. Fuller Co., 410 American Bldg. Estimated cost, $300,000.

ST. MICHAELS—The Board of Commissioners has had plans prepared for a sewage disposal plant, by L. J. Houston, engineer, Fredericksburg, Va. Estimated cost, $35,000. Address H. C. Lieb, president.

Massachusetts

WORCESTER — The Worcester Paper Box Co., 68 High St., plans to construct a 4-story, 40 x 110-ft. factory on Houchin Ave. by day labor. Estimated cost, $80,000. S. H. Pitcher Co., 44 Front St., engineer.

Michigan

DETROIT—The National Oxygen Co., 176 Oakland Ave., is having plans prepared for the construction of a 1-story, 40 x 122-ft. oxygen factory. Estimated cost, $10,000. Brown & Preston, 406 Empire Bldg., architects.

DETROIT—The Monarch Foundry Co., Greenwood Ave. and Grand Trunk Ry., is having plans prepared for the construction of a 1-story, 100 x 200-ft. gray iron foundry on Herrick St. and Vernor Avenue. H. M. Lane Co., Owen Bldg., engineer.

MANISTIQUE—Rome G. Brown, Metropolitan Life Bldg., Minneapolis, Minn., has awarded the contract for the construction of several reinforced-concrete and steel paper mill buildings, to Siems, Helmers & Schaffner, foot of Market St., St. Paul, Minn. Estimated cost, $250,000.

Minnesota

FOLEY—The village will soon award the contract for the construction of a sewerage system to include a disposal plant. Estimated cost, $13,400. Henry Bettendorf, clerk.

Missouri

ST. LOUIS — The Lowell Bleachery Co., 7718 Polk St., has awarded the contract for the construction of a 3-story, 103 x 105-ft. addition to its plant, to the Sutherland Building & Construction Co., 915 Olive St. Estimated cost, $50,000.

ST. LOUIS—The Scullin Co., 6700 Manchester Rd., will soon receive bids for the construction of a 2-story steel rolling mill at 1835 Knox St. Estimated cost, $30,000.

ST. LOUIS—The St. Louis Brass Manufacturing Co., Washington and Jefferson Aves., is having plans prepared for the construction of a 6-story, 175 x 300-ft. brass manufacturing plant on Washington Ave. Estimated cost, $500,000. E. S. Guth, president.

ST. LOUIS—The St. Louis Independent Packing Co., 3815 Chouteau Ave., has awarded the contract for the construction of a 4-story, 100 x 150-ft. by-product manufacturing plant on Vandeventer and Chouteau Aves., to A. H. Haeseler B. & C. Co., Wainwright Bldg. Estimated cost, $55,000. The company is in the market for pulverizers and other equipment.

Montana

BUTTE—The State Board of Examiners, Helena, will soon award the contract for the construction of a 2-story, 75 x 125-ft. metallurgical building, for the State School of Mines here. Estimated cost, $200,000. Floyd Hamill, 409 Lewisohn Bldg., architect. Noted May 15.

SHELBY—The city has awarded the contract for the construction of a sewage disposal plant, to the Two Miracle Concrete Co., 437 Ford Bldg., Great Falls, at $10,450.

Nebraska

BROKEN BOW—F. M. Skillman, city clerk, will receive bids until Sept. 23 for the construction of a sewerage system, including disposal plant and septic tanks. Estimated cost, $105,000. Grant, Fulton & Letton, 505 Bankers Life Bldg., Lincoln, engineers.

GIBBON—The Gibbon Roller Mill Co. has awarded the contract for the construction of a 3-story, 32 x 105-ft. mill, to the Schrack Construction & Engineering Co., 412 American Bank Bldg., Kansas City, Mo. Estimated cost, $55,000.

OMAHA—John Latener & Sons, 632 Bee Bldg., will receive bids Sept. 20 for the construction of a 6-story, 106 x 120-ft. hospital on 26th St. and Dewey Ave., to include filters and a water softener, etc., for the Lister Hospital, 14th St. and Capital Ave. Dr. E. C. Henry, in charge. Total estimated cost, $300,000.

New Jersey

HACKENSACK—The Hackensack Improvement Commission received bids for the construction of a sewage disposal plant, from Hauser & McIsaac, 18 East 41st St., $774,402; Simpson & Brown, 90 West St., $974,176, both contractors of New York City.

NEWARK—The Atlantic Smelting & Refining Co., Ave. R, has awarded the contract for the erection of plant, to Linde & Griffith, foot 4th Ave. Estimated cost, $100,000.

NEWARK—The Cocoanut Oil Co. nas awarded the contract for the construction of a 3-story factory, to J. Lowery, Jr., 108 West 40th St., New York City. Estimated cost, $150,000. Timmis & Chapan, 315 5th Ave., New York City, architects.

NEWARK—The Presto-O-Lite Co., 786 Frelinghuysen Ave., has awarded the contract for the construction of 8 buildings, the largest measuring 60 x 400 ft. and the smallest 30 x 40 ft., for the manufacture of storage batteries for automobiles, oxy-acetylene welding apparatus, etc., to James Mitchell, Inc., 76 Montgomery St., Jersey City.

New Mexico

HANOVER—The Republic Mining & Milling Co. plans to construct a steam turbo generator power plant, ball mill and flotation plant at its zinc mine here and is in the market for hoist, electrical equipment, crushers, flotation machines, etc. Estimated cost, $100,000. O. Wiser, manager.

LORDSBURG—The Bonney Consolidated Copper Co., Grant Co., plans to construct a complete concentration and flotation mill to have a daily capacity of 100 tons. The company is in the market for compressors, etc. J. P. Portens, superintendent.

SANTA RITA—The Grant County Copper Co. plans to install a flotation plant, etc., in its zinc mine here and is in the market for crushers, rollers, tables and vanners. Estimated cost, $20,000. H. B. Link, superintendent.

New York

ALBANY—The Albany Perforated Wrapping Paper Co., 1271 Broadway, has awarded the contract for the construction of a brick addition to its factory, to William G. Sheehan Construction Co., 28-30 De Witt St. Estimated cost, $18,000.

NIAGARA FALLS—The Carborundum Co., Buffalo Ave and 14th St., plans to build a 3-story 99 x 224-ft. carborundum plant on Buffalo Ave. Estimated cost, $150,000. L. J. Call, chief engineer.

ROCHESTER—The Board of Contract & Supply has awarded the contract for the construction of a new sewage disposal plant in the 23rd Ward, to Whitmore, Rauber & Vicinus, 279 South Ave. Estimated cost, $49,927. Noted Feb. 15.

North Carolina

GOLDSBORO—The Seminole Phosphate Co. has awarded the contract for the construction of a 1-story fertilizer factory, to D. J. Rose, Rocky Mount. Estimated cost, $22,000.

North Dakota

MINOT—The city plans an election Sept. 29 to vote on $280,000 bonds for the construction of an Imhoff tank and sewer mains. E. J. Thomas, Minot, engineer.

Ohio

ASHLAND—The Faultless Rubber Co. has awarded the contract for the construction of a 3-story, 83 x 168-ft. factory addition here, to J. R. Gloyd Co., 1815 East 33rd St., Cleveland. Estimated cost, $100,000. Noted Aug. 1.

CLEVELAND—The Enamel Products Co., 341 Eddy Rd., has awarded the contract for the construction of a 2-story, 40 x 180-ft. factory addition, to William Dunbar Co., 8201 Cedar Ave. Estimated cost, $10,000. Noted Sept. 1.

CLEVELAND—The General Bronze & Foundry Co., 4900 Hamilton Ave., plans to construct a 1-story, 100 x 125-ft. factory on East 49th St. Estimated cost, $60,000. Architect not selected.

CLEVELAND—The Glidden Varnish Co., West 110th St. and Berea Rd., has awarded the contract for the construction of a 2-story, 58 x 117 ft. factory addition at 11,410 Berea Rd., to J. R. Gloyd Co., 1816 East 33rd St. Estimated cost, $15,000.

CLEVELAND—The Standard Brass & Foundry Co., 990 East 67th St., has awarded the contract for the construction of a 2-story, 38 x 59-ft. office and shop to August Haase, 9028 St. Claire Ave. Estimated cost, $10,000.

CLEVELAND—The Superior Brick Co., Leader News Bldg., plans to construct a 2-story plant for the manufacture of bricks on Jennings Rd. Estimated cost, $500,000. Architect not selected.

Oklahoma

COLLINSVILLE—The city voted $40,000 bonds for the construction of a water filtration plant. Noted Sept. 1.

Oregon

BAKER—The Ben Harrison Mines Co. plans to enlarge its mining plant in Greenhorn District, also install flotation system and build machinery houses. Estimated cost, $50,000. W. C. Fellows, Baker, manager.

PORTLAND—The Central Waxed Paper Co., 5600 Fillmore St., Chicago, plans to construct a 3-story plant in North Portland. Estimated cost, $100,000. A. Christ, president.

Pennsylvania

LOCK HAVEN—The American Aniline Chemical Co. is making extensive improvements and additions to its plant which was recently operated by the Stanley Aniline Chemical Co. C. H. Dasher, manager.

NEW BRIGHTON—The New Brighton Board of Education is receiving bids for the construction of a 3-story, 90 x 135-ft. and 2-story, 82 x 98-ft. high school on Pierce and East 4th Sts. A chemical laboratory will be installed in same. W. G. Echles, New Castle, architect.

PITTSBURGH—W. W. Lawrence & Co., West Carson St., has awarded the contract for the construction of a paint factory, to E. A. Wehr, Highland Bldg. Estimated cost, $12,500.

Rhode Island

PROVIDENCE—The Revere Rubber Co., 355 Valley St., has awarded the contract for the construction of a 30 x 121-ft. factory addition on Eagle St., to Cruise & Smiley Construction Co., Main St., Pawtucket. Estimated cost, $20,000.

Texas

FORT WORTH—The Ok-In Producing & Refining Co. plans to construct a refinery, having an ultimate capacity of 5,000 bbl. of crude oil per day. Work will be done under supervision of John S. Blair, chief engineer, and J. T. Thompson, superintendent of construction.

Washington

BOSSBURG—The Big Bonanza Mine plans to expend $15,000 in development work and blocking out ore and installing concentrator. Olaus Jeldness, 2029 Second Ave., Spokane, manager.

NESPELEM—The Great Metals Mining & Milling Co. plans to improve its mill and is in the market for a filter press, clearing cells and storage bins. Elmer C. Williamson, manager.

SEATTLE—The Western Wall Board Co. plans to construct a 2-story, 50 x 100-ft. addition to its present plant at 4511 9th Ave., S. Estimated cost, $20,000.

West Virginia

FAIRMONT—The West Virginia Metal Products Co. will soon receive bids for the construction of a 1-story, 280 x 360-ft. factory, J. M. Boyle, 14 Wall St., New York City, engineer.

HUNTINGTON—C. C. Haywood and others, Ironton, Ohio, plan to build a plant for the production of bricks on 16th St. Rd. Estimated cost, $200,000.

HUNTINGTON—The Huntington Tumbler Co. plans to construct a 1-story, 82 x 272-ft. glass manufacturing plant on 15th St. Estimated cost, $100,000. A. Ford Dickey, architect.

HUNTINGTON—The Huntington Brick & Tile Co. plans to construct a 1-story brick plant at Westmoreland, to include elevators; main building 100 x 150 ft., also an 80 x 100-ft. dry kiln and 16 oval top kilns of 50-ft. diameter. Estimated cost, $150,000. T. M. Davidson, engineer.

British Columbia

BURNABY—The Gregory Tire & Rubber Co., 1404 Standard Bank Bldg., Vancouver, plans to build a 1-story, 100 x 240-ft. mill construction factory on Euclid Ave. and Collingwood St., here. Estimated cost, $50,000.

Ontario

BIRCHCLIFFE — Scarboro township plans to construct a waterworks system, to include filters, intake, etc. Estimated cost, $100,000. E. James, 57 Adelaide St., E., Toronto, engineer.

BROCKVILLE—The Consolidated Iron & Steel Corp., Ltd., 20 King St., E., Toronto, plans to construct an iron smelter, here. Estimated cost, $8,000,000.

CAPREOL—The Canadian National Rys., 27 Wellington St., E., Toronto, plans to install a chlorine or ultra violet sterilization system for swimming pool in connection with proposed 3-story, 72 x 120-ft. Y. M. C. A. building which it plans to construct. Total estimated cost, $75,000. A. F. Stewart, 27 Wellington St., E., Toronto, engineer.

TORONTO—H. B. Johnstone & Son, 774 Dundas St., E., will soon receive bids for the construction of a 3-story, 80 x 150-ft. tannery on Cameron Ave. Estimated cost, $130,000. John M. Lyle, Avondale Rd., architect.

Quebec

MONTREAL—The Booth Coulter Copper & Brass Co., 19 Queen St., has awarded the contract for the construction of a 2-story, 25 x 40-ft. factory, to S. Saratinal, 470 Amherst St. Estimated cost, $19,000.

Hawaii

HONOLULU—The Hawaiian Fertilizer Co. is having plans prepared for the construction of a 3-story, 60 x 130-ft. factory. T. Ronneberg, Crocker Bldg., San Francisco, Cal., engineer.

Coming Meetings and Events

THE AMERICAN CERAMIC SOCIETY will hold a meeting in Chicago, Sept. 24.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its Fall meeting in Chicago, Sept. 23 to 25 inclusive.

THE AMERICAN FOUNDRYMEN'S ASSOCIATION will hold its 1919 convention in Philadelphia, Sept. 29 to Oct. 4.

THE AMERICAN GAS ASSOCIATION will hold its annual convention and exhibtion of gas appliances and apparatus at the Hotel Pennsylvania, New York, Oct. 13 to 18.

THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its Fall meeting in Chicago, Ill., Sept. 22 to 27.

THE AMERICAN PEAT SOCIETY will hold its thirteenth annual meeting at Minneapolis, Minn., Sept. 22 to 24 inclusive.

THE AMERICAN STEEL TREATERS' SOCIETY will hold its first annual convention in Chicago, Ill., Sept. 22 to 27.

THE ELECTRIC FURNACE ASSOCIATION will hold a meeting in Chicago on Monday, Sept. 22.

THE ELECTRICAL EXPOSITION will be held in Grand Central Palace, New York City, Sept 24 to Oct. 4.

THE FIFTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES will be held in Chicago, Ill., Sept. 22 to 27 inclusive.

THE INSTITUTE OF METALS DIVISION of the A. I. M. E. will hold its next meeting in Philadelphia, Pa., Sept. 29 to Oct. 4.

THE NATIONAL SAFETY COUNCIL will hold its Eighth Annual Safety Congress in Cleveland, Oct. 1 to 4.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its Fall meeting in Chicago from Sept. 24 to 27.

Industrial Notes

CAPT. DONALD M. LIDDELL announces that on July 21 he again took up his work of chemical engineering, with offices in Rooms 1800-1802, 66 Broadway, New York City, and a laboratory at 961-965 Frelinghuysen Ave., Newark, N. J.

THE WHEELER & ENGINEERING Co., Carteret, N. J., elected Mr. J. J. Brown, formerly vice-president and general manager, as president, at its board of directors meeting July 8. Mr. J. J. Brown succeeds Charles W. Wheeler, recently deceased. Mr. H. S. Brown of 50 Congress St., Boston, was elected vice-president.

THE HERCULES ENGINEERING CORP., of Chicago and New York, announces that Major M. G. Donk has joined its staff. His work is of a special character on the installation of equipment. Dr. J. T. Brewster, who has acted in a consulting capacity with this corporation for the last three years, succeeds Mr. A. H. Alberger as head of the technical and engineering department.

BRIGGS & TURIVAS, of Chicago and New York, operators in iron and steel scrap and salvage, have purchased from the Imperial Munitions Board of Canada the entire plant and property of the British Chemical Co., Ltd., located at Trenton, Province of Ontario, Canada. A Canadian corporation under the name of Briggs & Turivas of Canada, Ltd., and capitalized at $1,200,000, has been formed, with main offices in the C. P. R. Bldg. at Toronto, Ontario, and a branch office at Trenton, Ontario. The property consists of 255 acres and fronts the Trenton River, a navigable stream, with Lake Ontario as its source. Three trunk line railroads enter the plant. The British Chemical Company was formed and built during the war at an outlay of approximately $8,000,000. It is completely modern in all respects. The equipment consists principally of two separate and complete sulphuric acid chamber plants, sulphuric acid concentrators, a nitric acid plant, an alcohol rectifying plant, two refrigerating plants, a smokeless powder plant, a complete high pressure fire system, two miles of narrow gage trackage with electric locomotives and trucks, two boiler houses, electrical equipment, warehouses, storage tanks, administration buildings, etc. The plant had a daily capacity of over 100 tons of sulphuric acid, 75 tons of nitric acid, 25 tons of finished smokeless powder and 45 tons of ethyl alcohol. The new owners are as yet undecided as to the extent of the operations of the plant for the future, but it is expected that the powder manufacturing apparatus and equipment, and possibly the nitric acid plant, will be dismantled and disposed of, allowing the sulphuric acid plants to stand, there being a good market in Canada for sulphuric acid for the manufacture of fertilizer, for which the demand in that country is great.

THE FATE-ROOT-HEATH CO. announces that on July 1, 1919, it succeeded to the business of the J. D. Fate Co. and the Root-Heath Mfg. Co., the consolidation being made to meet the growing demand for Plymouth industrial locomotives, clay-working machinery and other Plymouth products. The officers of the new company are: President, J. A. Root; vice-president and general manager, C. E. Heath; second vice-president, W. F. Root; secretary, P. H. Root; treasurer, H. R. Sykes, and sales manager, H. J. Votan.

THE WORTHINGTON PUMP & MACHINERY CORP., New York, announces its purchase of the plant, patterns, accounts, patents and other assets of the Epping-Carpenter Pump Co. located at 10 43rd St., Pittsburgh, Pa., which will be known as the "Epping-Carpenter Works" of the Worthington Pump & Machinery Corp. Orders and contracts now in hand will be completed by the Worthington Pump & Machinery Corp., and all further business will be for its account.

BUCKMAN & PRITCHARD, INC., announces that a postoffice has been established at

Mineral City, Fla., and requests that all communications be sent there with the exception of telegrams, which should be sent to Pablo Beach, Fla.

THE BRONZE ALUMINA CORP. has removed from Tonawanda, N. Y., to a new shop in Buffalo.

THE ELECTROLYTIC OXY-HYDROGEN LABORATORIES, INC., announces the formation of a sales and manufacturing company under the name of the Electrolabs Company. The Electrolytic Oxy-Hydrogen Laboratories, Inc., will continue in charge of the laboratories and maintain a technical supervision over the work of the new company. The general offices and works of both companies have been moved from Dayton, Ohio, into larger quarters at 2635 Penn Ave., Pittsburgh, Pa., to provide increased facilities for its expanded business. The general sales offices are being continued at 15 William St., New York City, and branch sales offices have been opened in the Morris Bldg., Philadelphia, and the Merchants Exchange Bldg., San Francisco. Mr. I. H. Levin continues in charge of the technical and research work, and Mr. D. J. Tonkonogy in general charge of sales.

THE LIVINGSTON REFINERS CORP. of Tulsa, Okla., has just placed an order for 100 "Pennsylvania" tank cars with the Pennsylvania Tank Car Co. of Sharon, Pa., to be used in the transportation of the corporation's petroleum products.

THE GREEN ENGINEERING CO., East Chicago, Ind., announces the appointment of the firm of Bull & Livensparger as its sales representatives in Chicago and northern Illinois territory. On Aug. 1 they took charge of the Chicago sales office at 14 E. Jackson Blvd. This company also announces the appointment of Mr. E. L. Sullivan as representative in the Pittsburgh district.

MR. WILLIAM LANYON announces that he has sold the plant of the ROBERT LANYON ZINC & ACID CO., at Hillsboro, Ill., to the Eagle-Picher Lead Co.

THE BLAW-KNOX CO., Pittsburgh, Pa., announces the appointment of Mr. L. C. Murray as engineer-salesman in the "Knox" department. This company also announces the opening of an office in the Little Bldg., Boston, Mass., and in the Owen Bldg., Detroit, Mich. Mr. A. W. Ransoms will have charge of the New England office, and Mr. H. J. Desson will be manager of the Michigan district.

THE CHICAGO PNEUMATIC TOOL CO. plans moving its general offices from Chicago to New York, and is erecting an office building at 6-8 East 44th Street, New York City. This company also announces the removal of its Cincinnati office from the Mercantile Library Bldg. to the Walsh Bldg.; the appointment of Mr. J. L. Canby as district manager of sales at Chicago, succeeding Mr. Nelson B. Gatch, who has been transferred to New York as district manager of sales; and the appointment of Mr. Fred Gelbauer as special Navy Yard representative, with headquarters at the Philadelphia office.

THE FOUNDATION CO., New York City, announces that at a recent meeting of the board of directors, Franklin Remington was elected chairman of the board, John W. Doty was elected president of the company, and H. J. Deutschbein first vice-president and general manager.

CHAS. BUTTERS & CO., LTD., New York, announces that Mr. Chas. Butters, who has hitherto been acting as managing director, is no longer associated with the company.

THE NATIONAL ASSOCIATION OF PURCHASING AGENTS through its standardization committee is endeavoring to bring about the adoption of standard forms for invoices, purchase orders, acknowledgments and notices of shipment. Any one interested in this movement should communicate with the chairman of the committee, Mr. W. L. Chandler, Dodge Sales & Engineering Co., Mishawaka, Ind.

THE ELECTRIC FURNACE CONSTRUCTION CO., Philadelphia, advises the receipt of an order from the Hammond Steel Co., Syracuse, N. Y., for one 3-ton furnace for the manufacture of high-grade tool steels; the installation of a "Greaves-Etchells" furnace in the Hongkong Steel Foundry Co., China; an order from Capt. Teixeira, a member of the Brazilian Military Commission, through Fenwick Freres & Co., New York, for a "Greaves-Etchells" electric furnace; an order received from a new steel castings plant, the Dodge Steel Co., Philadelphia, which installation will be a 3-ton furnace of the latest "Greaves-Etchells" type.

THE CASSEL CYANIDE CO., of Glasgow, will incorporate a subsidiary company in Canada.

New Publications

THE ANNUAL REPORT on the Mineral Production of Canada, During the Calendar Year 1917. Issued by the Canadian Department of Mines, Ottawa.

THE CARBONIZATION OF MISSOURI CANNEL COALS. By Howard Leroy Dunlap, assisted by Karl Kenneth Kershner and Vivian Xly Smiley. Vol. 5, No. 1, of the technical series issued by the School of Mines and Metallurgy, University of Missouri, Rolla, Mo.

A REFERENCE LIST OF THE ELECTROCHEMICAL INDUSTRY is the title of a copyrighted pamphlet issued by the American Electrochemical Society, South Bethlehem, Pa. This pamphlet contains a comprehensive list of firms engaged in that industry in the United States and Canada and also gives a list of the products of the industry.

THE SENSITIVENESS OF SOME CYANIDE REACTIONS. By John B. Ekeley and Icie C. Macy. Published by the Colorado Scientific Society, Denver, June, 1919.

A CONTRIBUTION TO THE HYDROLOGY OF THE SAN LUIS VALLEY, COLORADO. By William P. Headden. Published by the Colorado Scientific Society, June, 1919.

AN INVESTIGATION OF THE STRESSES IN THE TRANSVERSE BENT FOR STEEL MILL BUILDINGS. By C. S. Sperry. Published by the Colorado Scientific Society, June, 1919.

EMPLOYMENT MANAGEMENT, EMPLOYEE REPRESENTATION AND INDUSTRIAL DEMOCRACY. A pamphlet issued by the U. S. Department of Labor, Working Conditions Service, which is an address delivered before the National Association of Employment Managers, Cleveland, May 23, 1919. By W. M. Leiserson.

WAR TRADE BOARD JOURNAL, with official rulings and announcements of the Board and its Bureau, issued by the War Trade Board, June, 1919.

READJUSTMENT AND RECONSTRUCTION ACTIVITIES IN FOREIGN COUNTRIES is the title of a booklet issued May 1, 1919, by the United States Council of National Defense.

THE AMERICAN LIBRARY ASSOCIATION (Library War Service), Washington, D. C., has issued a booklet entitled "One Thousand Technical Books", compiled by Herbert L. Cowing, which aims to fit discharged American soldiers and sailors into useful civilian occupations. The list includes books on engineering, basic subjects, civil engineering, mechanical engineering, electric engineering, building, mining and metallurgy, chemical technology and miscellaneous.

UTILIZATION OF WASTE SULPHITE LIQUOR is the title of Bull. 66 issued by the Forestry Branch, Department of the Interior, Canada.

NEW UNITED STATES GEOLOGICAL SURVEY PUBLICATIONS: II:30, Stone in 1917, by G. F. Loughlin and A. T. Coons (Mineral Resources, 1917, Part II), published June 20, 1919; II:3, Gems and Precious Stones in 1918, by Waldemar T. Schaller (Mineral Resources, 1918, Part II), published July 16, 1919; II:2, Sand-Lime Brick in 1918, by Jefferson Middleton (Mineral Resources, 1918, Part II), published June 10, 1919; The Farnham Anticline, Carbon County, Utah, by Frank R. Clark; Bull. 711-A, which is a contribution to economic geology, 1919, Part II, published July 3, 1919.

THE FEDERAL BOARD FOR VOCATIONAL EDUCATION is issuing a series of Opportunity Monographs for disabled soldiers, sailors and marines. Series No. 29 is on "Drafting" and No. 40 on "Electric Welding."

NEW WAR INDUSTRIES BOARD PUBLICATIONS: Bull. 45, Price of Mineral Acids, by H. L. Lewenberg; Bull. 46, Prices of Heavy Chemicals, by H. L. Lewenberg; Bull. 47, Prices of Miscellaneous Inorganic Chemicals, by W. B. Meldrum; Bull. 50, Prices of Essential Oils, Flavoring and Perfumery Materials, by W. B. Meldrum; Bull. 54, Prices of Drugs and Pharmaceuticals, by W. Lee Lewis and F. W. Cassebeer; Bull. 55, Prices of Proprietary Preparations, by W. Lee Lewis and F. W. Cassebeer. No. 7, Prices of Chemicals, by F. E. Breithut; No. 53, Prices of Coal Tar Crudes, Intermediates, and Dyes, by Webster N. Jones and F. W. Cassebeer; No 38, Prices of Clay Products, by Homer Hoyt.

NEW BUREAU OF STANDARDS PUBLICATIONS: No. 124, Constitution and Microstructure of Silica Brick and Changes Involved Through Repeated Burnings at High Temperatures, by Herbert Insley and A. A. Klein, issued July 11, 1919; No. 334, New Forms of Instruments for Showing the Presence and Amount of Combustible Gas in the Air, by E. R. Weaver and E. E. Weibel, issued June 23, 1919; No. 335, Effect of Rate of Temperature Change on the Transformation in an Alloy Steel, by Howard Scott, issued July 10, 1919.

NEW BUREAU OF MINES PUBLICATIONS: Tech. Paper 212, The Determination of Combustible Matter in Silicate and Carbonate Rocks, by A. C. Fieldner, W. A. Selvig and G. B. Taylor; Tech. Paper 216, Vitiation of Garage Air by Automobile Exhaust Gases, by G. A. Burrell and A. W. Gauger; Tech. Paper 220, Burning Steam Sizes of Anthracite, With or Without Admixture of Soft Coal, reprint of Engineering Bull. No. 5, prepared by the United States Fuel Administration in collaboration with the Bureau of Mines; Bull. 176, Recent Developments in the Absorption Process for Recovering Gasoline from Natural Gas, by W. P. Dykema; Bull. 178C, Petroleum Investigations and Production of Helium, advance chapter from Bull. 178, War Work of the Bureau of Mines, by Van H. Manning; War Minerals Investigation Series No. 17, Preparation of Manganese Ore, by W. R. Crane.

Stocks and Bonds

Closing Bid and Asked Quotations Sept. 12, on N. Y. Stock Exchange

CHEMICAL COMPANIES

	Bid	Ask		Bid	Ask
Am.Ag.Ch....	98	100	Mat.Al Wk..	31	34
do.pf.....	...	98	Ten. C. & C.	13	13½
Barrett Co...	126	128	Un. Dyewood	50	...
do.pf.....	112	114	do.pf.....	96	...
Gen. Chem...	...	180	Va.-Car.Ch..	81½	82½
do.pf.....	101	104	do.pf.....	113½	114½
Int.Ag.Ch....	25	27			
do.pf.....	81½	83			

Bonds

Am. Ag. Ch., 1st cv. 5s, '28.....	94	100
Am. Ag. Ch., cv. db. 5s, '24.....	101½	107
Int. Ag. Ch., 1 mtg. & col. tr. 5s, '32....	83	83½
Va.-Car. Ch., 1 mtg. 5s, '23.....	95½	95½
Va.-Car. Ch., cv.db. 6s, '24.....	102	103

PETROLEUM COMPANIES

	Bid	Ask		Bid	Ask
Asso. Oil Co..	90	91	P-A Pet & Tr	121	121½
Cal. Pet.....	53	53½	do. pf.....	...	...
do. pf.....	85½	86	Pierce Oil....	21½	21¾
Col. G. & E..	62½	62¾	Royal Dutch.	97½	...
Mex. Pet.....	207¾	207½	Sinclair O&R.	60	60¼
do. pf.....	107	112	Texas Co....	265½	267
Ohio Cit. Gas.	53½	53½	Tex. Pac. Ld. Tr.....	300	500
do. pf.....	...	...			
Ohio Fuel S...	50	50¼	Tidewater Oil	238	245
Okla. P. & R.	10¼	10¾			

Bonds

Columbia Gas & Electric, 1 5s, '27.....	89	89½
Col. G. & El., std. 1 5s, '27.....	87	89½
Pan-Am. Pet. & Tr. 1 6s, '19-'27.....	180	...
Pierce Oil, cv. db. 6s, '24.....	105½	105½
Pierce Oil, cv. 5% Notes, '20.....	105½	120
Sin. O. & R. 1 In. 7s, '20, with stk. war...	...	...
Sin. O. & R. 1 In. 7s, '20 without stk war.	...	...
Texas Co., db. 6s, '31.....	102½	102¾
Union Oil of Cal. 1 5s, '31.....	94½	95
United Fuel Gas 1 mtg. 6s, ser. A., '36..	96	98

IRON AND STEEL SECURITIES

	Bid	Ask		Bid	Ask
Am. St. F....	39½	40	Pitts. Ste. pf.	89¾	92½
Beth. Steel..	80	85	Rep. Iron & Steel.....	91¾	92
do. class B..	91¾	91½	do. pf.....	105½	107
do. pf., 8%.	111½	114	Sloss Sheff. I. & S.....	64	65½
do. pf., 7%.	107	110	do. pf.....	87	92
Central Fdry.	27	31	Superior Steel	43	43½
do. pf.....	55	59	do. 1 pf....	102	105
Col. F. & I...	45	45½	Trans. & W. Steel.....	57	58
do. pf.....	...	...	Un. Alloy St.	50½	52
Cruc. Steel...	183½	184	U.S.C.I.P.&F.	31½	32
do. pf.....	103	106	do. pf.....	55	56
Great No. Ore	43½	44	U. S. Steel...	103½	104
Gulf Sta. Steel	60½	61	do. pf.....	114½	114½
do. 1 pf....	94	98	Va. Coal,I&C	60	65
Lack. Steel...	82½	83			
Mid.St.&Ord.	51	51½			
Nova Scotia Steel.....	75½	76			

Bonds

Beth. Steel, 1 ext. gtd. S.F. 5s, '26.....	96	98
Beth. Steel, 1 In. ref. 5s, Ser. A, '42.....	88½	92
Beth. Steel, P. M. & I. S. F. 5s, '36.....	86	86½
Buff & Susq. Iron, 1 S. F. 5s, '32.....	...	91½
Buff & Susq. Iron, deb. 5s, '27.....	90	...
Cent. Found., 1 mtg. S. F. 6s, '21.....	86	86½
Col. F. & I., gn. S. F. 5s, '43.....	89½	92
Ill. Steel, db. 4½s, '40.....	84½	85½
Ind. Steel, 1 mtg. gtd. 5s, '52.....	...	94½
Lack. Steel, 1 5s, '23.....	97	98
Lack. Ste., 1 con. mtg. cv. 5s, Ser. A, '50.	92½	95
Mid. St. & Ord., clt. cv. S. F., 5s, '36....	87½	87½
Nat. Tube, 1 mtg. gtd. 5s, '52.....	94½	...
Rep. I. & S., S. F. mtg., 5s, '40.....	95	95½
Tenn. C. & I. R.R. 'gn. 5s, '51.....	89½	89½
U. S. Steel, S. F. 5s, 63.....	99½	99½
Va. C., I. & C., 1 5s. '49.....	84½	85½